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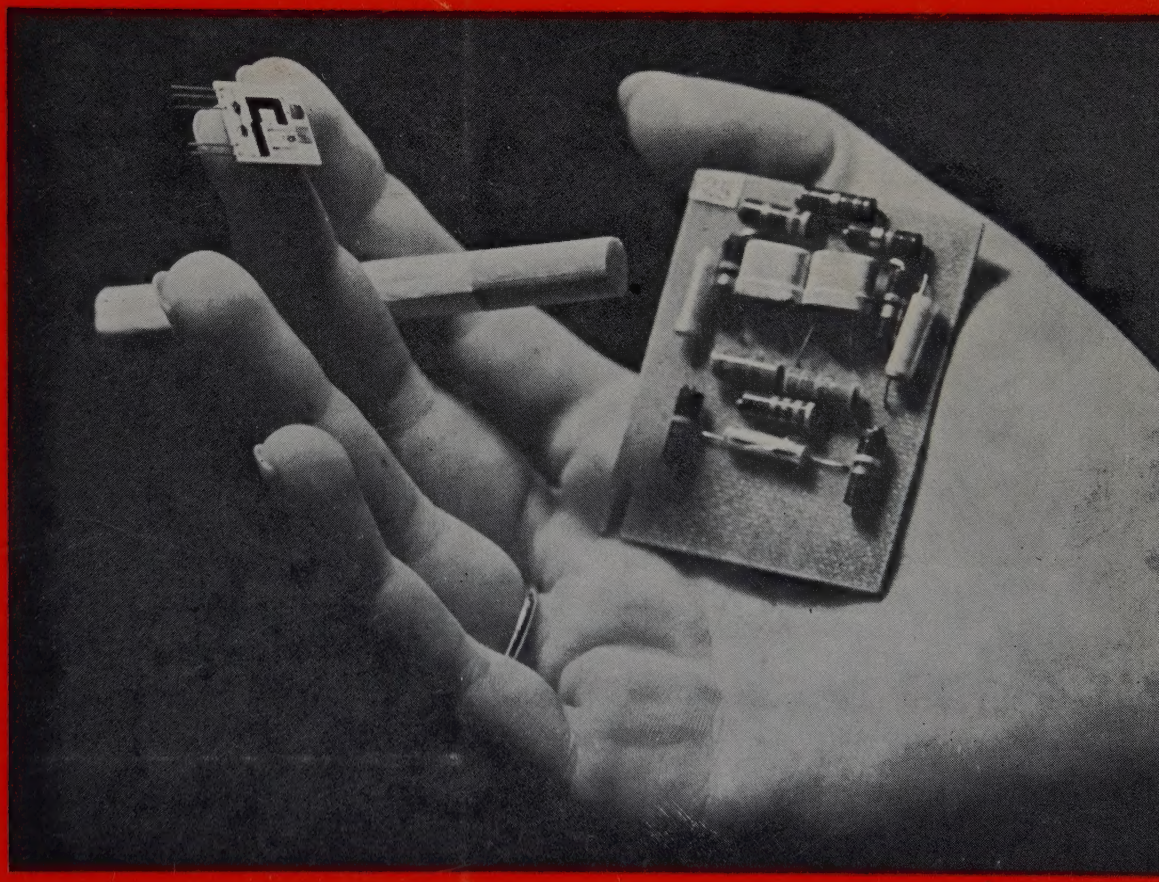

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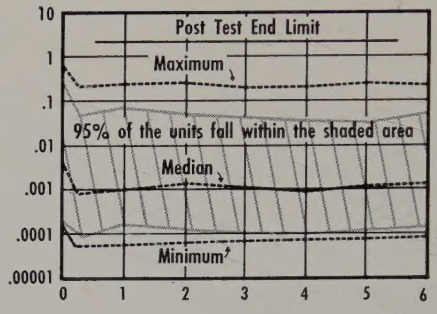
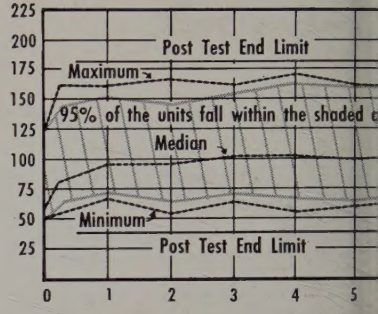
PARAMETER MEASURED	TEST CONDITIONS	ACCEPTANCE LIMIT MIN	ACCEPTANCE LIMIT MAX
I_{CBO}	$V_{CB} = 20$ vdc, $I_E = 0$, $T_A = 25°C$	—	2 μa

PARAMETER TEST CONDITIONS AND LIMITS

PARAMETER MEASURED	TEST CONDITIONS	ACCEPTANCE MIN	ACCEPTANCE
h_{FE} pulse	$V_{CE} = 5$ vdc, $I_C = 10$ ma, $T_A = 25°C$	45	





I_{CBO} and h_{FE} characteristics of a sample of 60 TI 2N337 and 2N338 units ov 6-week period. These tests are conducted by TI's independently operated Qua Assurance Branch, and are representative of the complete parameter beha test information in the Silicon Transistor Reliability Data brochure listed be

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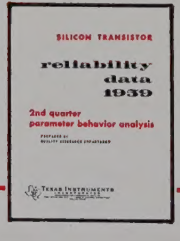
Description of characteristics 2N338 switching and general-purp unit and 3N34 and 3N35 very-hi frequency tetrodes.



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Complete parameter analysis of TI 2N332 through 2N — a graphic presentation of parameter behavior with t when one type transistor from a series is subjected to sta tests. The graphs above are representative of this da

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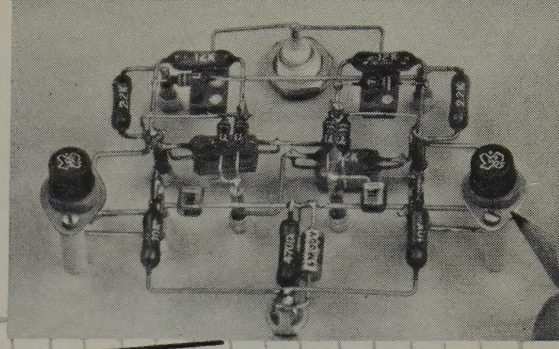

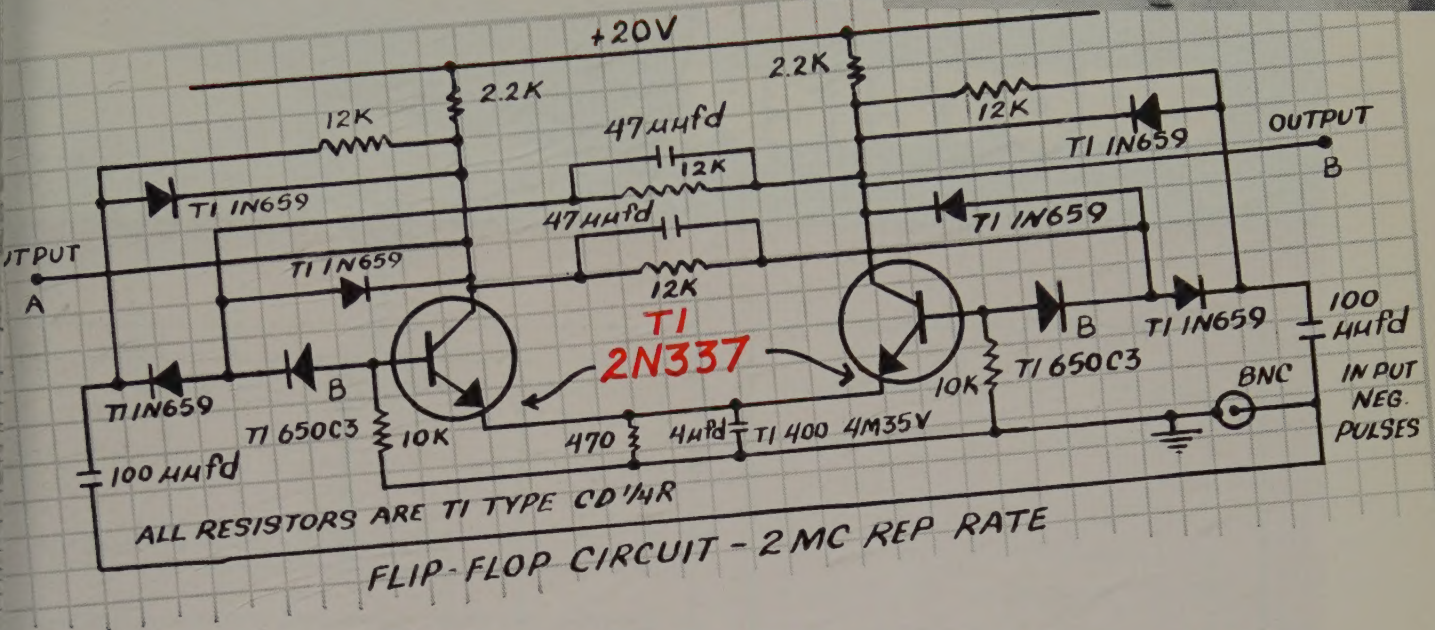

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Over four years of mass production and successful use in the most advanced military and industrial applications have proved the value of the TI 2N337 series. Consider TI's guaranteed specs when you select devices for your next transistor circuit. These units are immediately available in production quantities or from large stocks at all authorized TI distributors.

sign characteristics at 25° C ambient (except where advanced temperatures are indicated)

		test conditions		2N337 min	2N337 design center	2N337 max	2N338 min	2N338 design center	2N338 max	unit
I_{CBO}	Collector Cutoff Current	V_{CB} = 20V	I_E = 0	—	—	1	—	—	1	μA
	at 150°C	V_{CB} = 20V	I_E = 0	—	—	100	—	—	100	μA
BV_{CBO}	Breakdown Voltage	I_{CB} = 50μA	I_E = 0	45	—	—	45	—	—	V
BV_{EBO}	Breakdown Voltage	I_{EB} = 50μA	I_C = 0	1	—	—	1	—	—	V
h_{ib}	Input Impedance	V_{CB} = 20V	I_E = −1mA	30	50	80	30	50	80	Ohm
h_{ob}	Output Admittance	V_{CB} = 20V	I_E = −1mA	—	0.2	1	—	0.2	1	μmho
h_{rb}	Feedback Voltage Ratio	V_{CB} = 20V	I_E = −1mA	—	200	2000	—	300	2000	X10⁻⁶
h_{fb}	Current Transfer Ratio	V_{CB} = 20V	I_E = −1mA	0.95	0.985	—	0.975	0.99	—	—
h_{FE}	DC Beta	V_{CE} = 5V	I_C = 10mA	20	35	55	45	80	150	—
$f_{\alpha b}$	Frequency Cutoff	V_{CB} = 20V	I_E = −1mA	10	20	—	20	30	—	mc
C_{ob}	Collector Capacitance*	V_{CB} = 20V	I_E = −1mA	—	1.2	3	—	1.2	3	μμf
R_{cs}	Saturation Resistance†	I_B ‡	I_C = 10mA	—	75	150	—	75	150	Ohm
h_{fe}	Current Transfer Ratio	V_{CB} = 20V	I_E = −1mA, f = 2.5mc	14	22	—	20	24	—	db
t_r	Rise time§			—	0.05	—	—	0.06	—	μsec
t_s	Storage Time			—	0.02	—	—	0.02	—	μsec
t_f	Fall time			—	0.08	—	—	0.14	—	μsec

* Measured at 1 mc † Common Emitter ‡ I_B = 1mA for 2N337, 0.5mA for 2N338 § Includes delay time (t_d)

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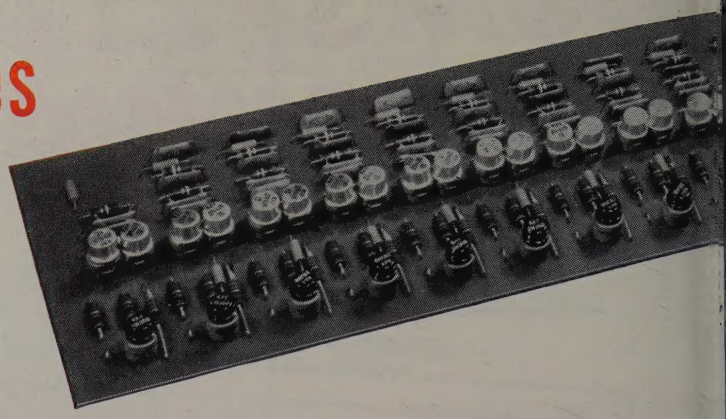
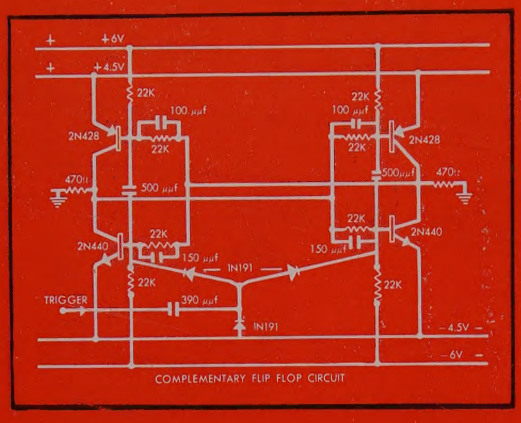
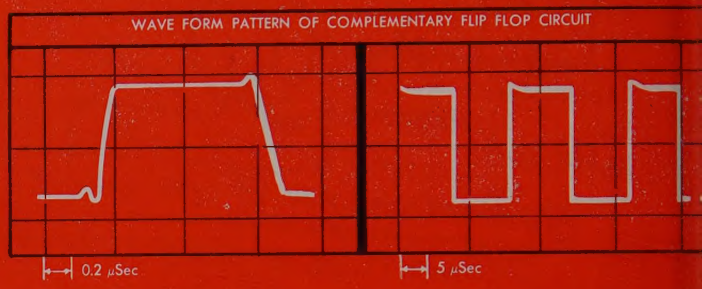
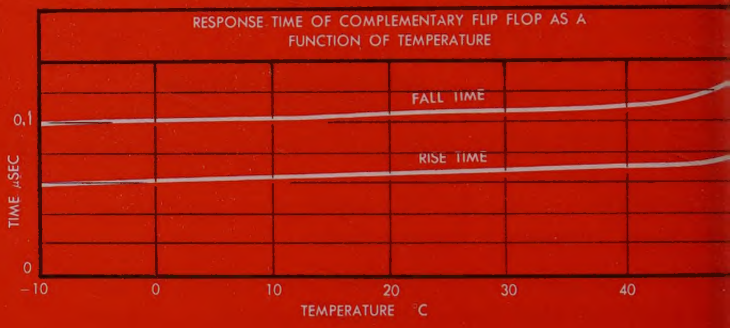


COMPLEMENTARY FLIP FLOP CIRCUIT







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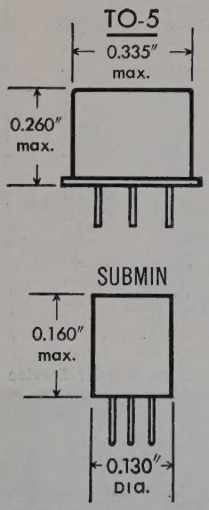

GERMANIUM PNP ALLOY — TO-5 CASE

Type	V_{CE} Volts	$f_{\alpha b}$ Avg. Mc	H_{FE1} I_B = 1MA V_{CE} = 0.25V	H_{FE2} Min. I_B = 10MA V_{CE} = 0.25V	Rise* Time Max.
2N404	−24	12	—	—	—
2N425	−20	4	20–40	10	1.0
2N426	−18	6	30–60	10	0.55
2N427	−15	11	40–80	15	0.44
2N428	−12	17	60	20	0.33
2N1017	−10	22	80	20	0.27

*I_C = 50MA; I_{B1} = 5MA; R_L = 200Ω I_{B2} = 5MA

GERMANIUM NPN ALLOY — TO-5 CASE

Type	V_{CE} Volts	$f_{\alpha b}$ Avg. Mc	H_{FE} Min. I_C = 50MA V_{CE} = 1.0V	Ris Ti A μ
2N438	25	6	20	0
2N439	20	11	30	0
2N440	15	17	40	0

**I_{B1} = I_{B2} = IMA; I_C = 10MA; R_L = 1KΩ

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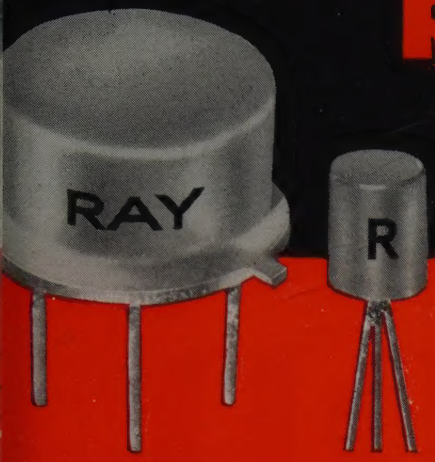
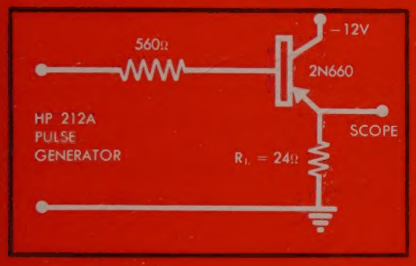
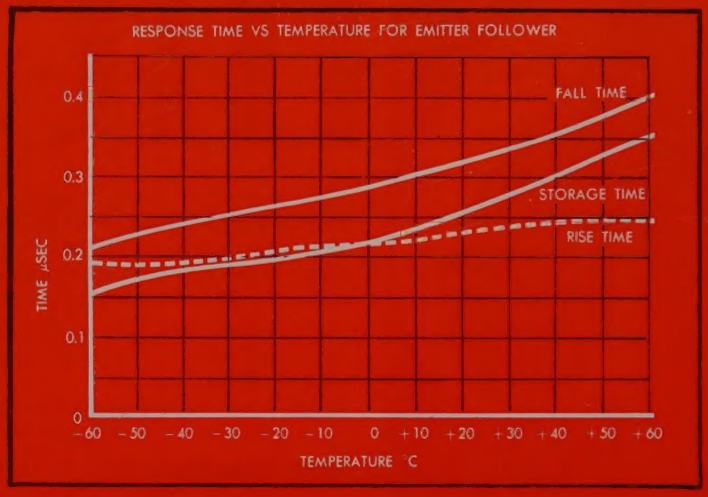


EMITTER FOLLOWER CIRCUIT





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High Current Switches

GERMANIUM PNP ALLOY — TO-5 CASE

Type	V_{CE} Volts	$f_{\alpha b}$ Avg. Mc	H_{FE1} I_B = 1MA V_{CE} = 0.25V	H_{FE2} Min. I_B = 10MA V_{CE} = 0.35V
2N658	−24	5	25–80	15
2N659	−20	10	40–110	25
2N660	−16	15	60–150	40
2N661	−12	20	80	55
2N662	−16	8	30	18

Subminiature Switches

GERMANIUM PNP ALLOY — SUBMIN CASE

Type	V_{CE} Volts Volts	$f_{\alpha b}$ Avg. Mc	H_{FE1} I_B = 1MA V_{CE} = 0.25V	H_{FE2} Min. I_B = 10MA V_{CE} = 0.35V	Rise* Time Max.
CK25	−20	4	20–40	10	1.0
CK26	−18	6	30–60	10	0.55
CK27	−15	11	40–80	15	0.44
CK28	−12	17	60	20	0.33

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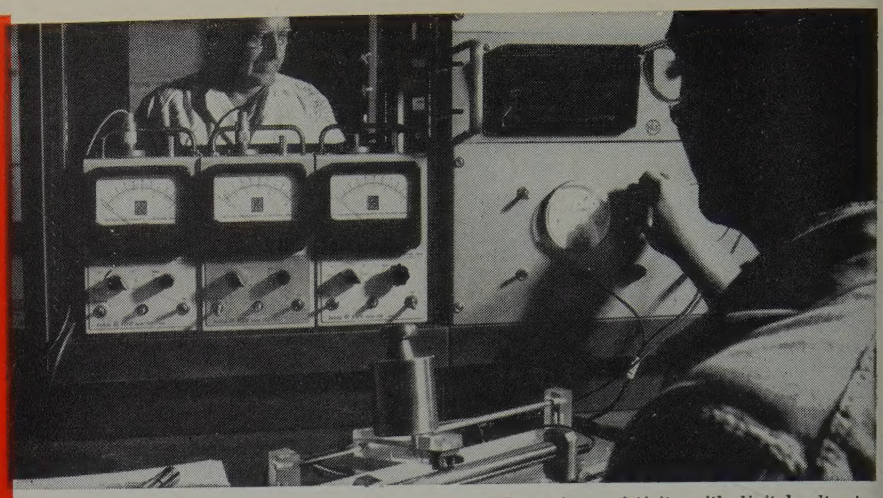

Measuring resistivity with digital voltmeter at Merck Control Laboratory, Danville, Pa.

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***NOTE:** *Extended resistivity range.*

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Front Cover

Printed micro-circuit process developed by James R. Nall and his co-workers of Fairchild Semiconductor Corp. is similar to the photolithographic technique used in making offset (or lithograph) printing plates. A photographic process is used to create a pattern of circuitry and components on a ceramic wafer. The image is then developed by exposure to a special light to complete the process. A series of these wafers can be stacked together to form a complete circuit sub-assembly. Due to extreme miniaturization, the work must be done under microscopes.

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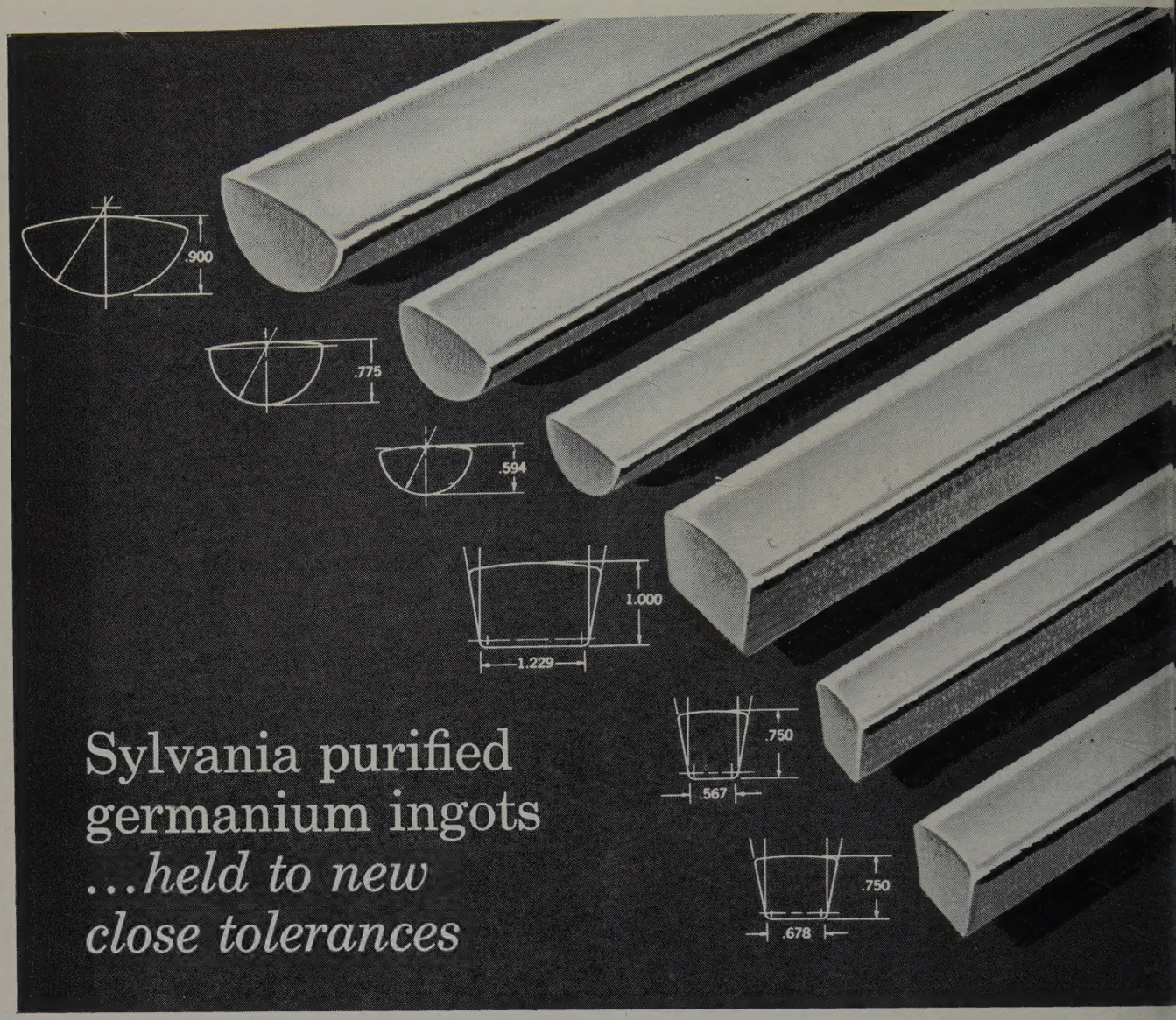

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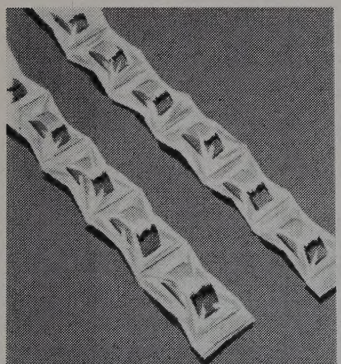

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he 2N706 is also extraordinary as a success story in eople—solid-state physicists, physical chemists, metal-rgists, electrical engineers, mechanical engineers and dustrial engineers. Free flow of ideas and enthusiasm oduced an accumulation of advanced semiconductor chnologies at an unprecedented rate. From the be-nning, only two years ago, the 2N706 was the goal. route, these technologies resulted in the production of eight other silicon transistors. These devices have clearly established Fairchild as the leader in advanced semiconductor development.

Step by step, the Fairchild program was planned and held in focus by a top management team of advanced degree scientists. And now, this same program is being zeroed in on new targets, among them Esaki diodes and integrated solid-state circuitry. If yours is a relevant background and you like the way we work, why not drop us a line? We would like to hear from you.

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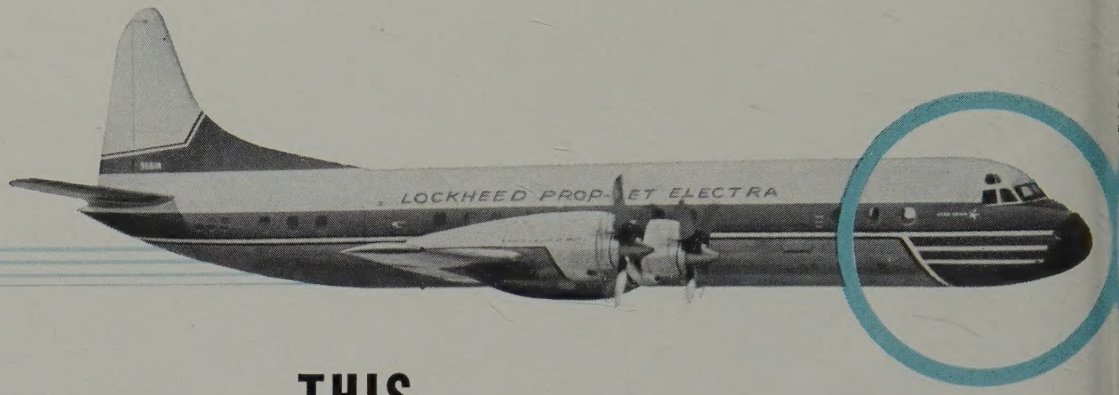
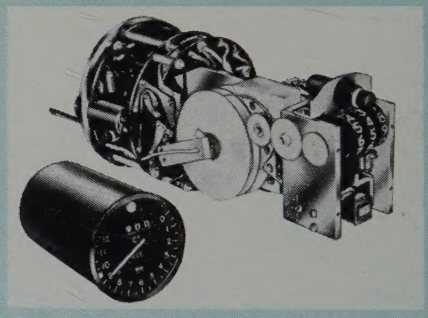
HOFFMAN SEMICONDUCTOR APPLICATION CASE HISTORY



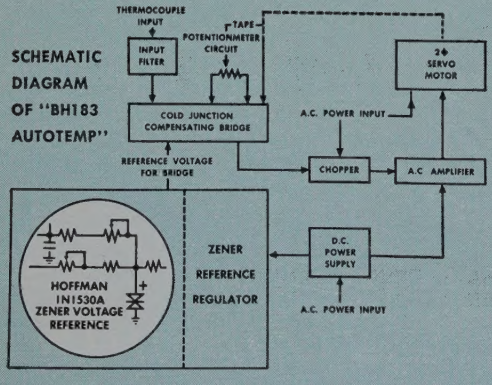
THIS VOLTAGE STABILITY PROBLEM HAD TO BE SOLVED

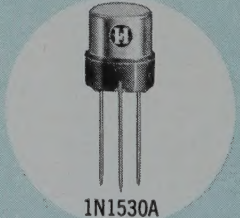
FOR CIRCUIT RELIABILITY IN A JET ENGINE TEMPERATURE INDICATOR



Hoffman Zener Voltage Reference Elements were the solution

SCHEMATIC DIAGRAM OF "BH183 AUTOTEMP"





Engineers of the B & H Instrument Company, Fort Worth, Texas, required an extremely reliable voltage reference device for their BH183 AutoTemp jet engine temperature indicator, used in the Lockheed Electra. . . . They chose a Hoffman 1N1530A Zener Reference Element, because of its STABLE characteristics even when subjected to widely varying environmental conditions.

The low 8.4 volt, zener operating voltage of Hoffman 1N430 and 1N1530 Zener Reference Elements, makes them uniquely suited for use in circuits which are operating at a low D.C. voltage level (from 10 to 30 volts). The units have a voltage stability of ±0.1%, or less, over a temperature range from −55°C to +100°C, at 10mA.

There are over 180 Hoffman Zener Devices available . . . now in the widest possible range of voltage and power dissipation ratings. Write us . . . tell us your problem . . . the Hoffman semiconductor sales engineer in your area will provide the solutions.

If you need a job in electronics done quicker and better, contact

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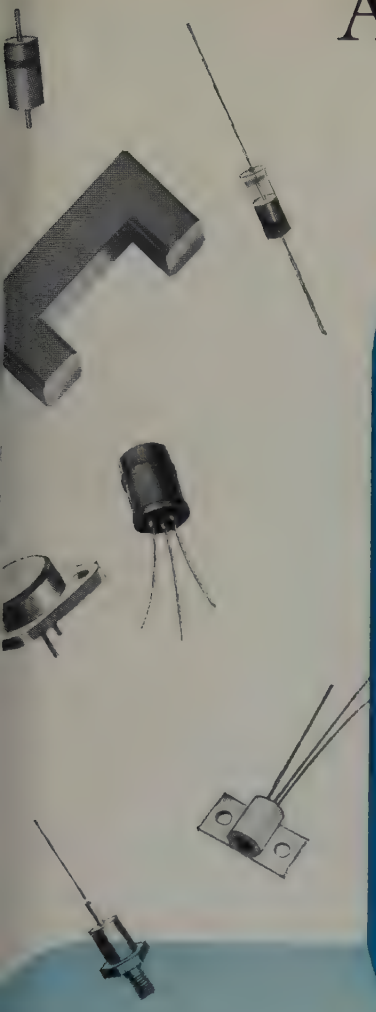
Hoffman Electronics
CORPORATION
SEMICONDUCTOR DIVISION
930 PITNER AVENUE EVANSTON, ILLINOIS

An important message to manufacturers of



semi-conductors
electronic tubes
thermistors
ferrites

J. T. BAKER ELECTRONIC CHEMICALS

Acetic Acid, Glacial	Cobalt Carbonate	Nickelous Nitrate
Acetone	Cobalt Oxide	Nickelous Sulfate
Aluminum Nitrate	Cobalt Nitrate	Nitric Acid
Aluminum Sulfate	Ether, Anhydrous	Petroleum Ether
Ammonium Carbonate	Hydrochloric Acid	Potassium Dichromate
Ammonium Chloride	Hydrofluoric Acid	Potassium Hydroxide
Ammonium Hydroxide	Hydrogen Peroxide,	iso-Propyl Alcohol
Ammonium Phosphate	30% and 3% Solution	Radio Mixture No. 3
Antimony Trioxide	Lithium Carbonate	Silicic Acid
Barium Acetate	Lithium Chloride	Sodium Carbonate
Barium Carbonate	Lithium Nitrate	Sodium Chloride
Barium Fluoride	Lithium Sulfate	Sodium Hydroxide
Barium Nitrate	Magnesium Carbonate	Sodium Phosphate Dibasic
Benzene	Magnesium Chloride	Strontium Carbonate
Boric Acid	Magnesium Oxide	Strontium Nitrate
Cadmium Chloride	Manganese Dioxide	Sulfuric Acid
Cadmium Nitrate	Manganese Nitrate	Toluene
Cadmium Sulfate	Manganese Sesquioxide	Trichloroethylene
Calcium Carbonate	Manganous Carbonate	Triple Carbonate
Calcium Chloride	Methanol	Xylene
Calcium Fluoride	Nickel Carbonate	Zinc Chloride
Calcium Nitrate	Nickel Oxide, Black	Zinc Nitrate
Calcium Phosphate	Nickel Oxide, Green	Zinc Oxide
Carbon Tetrachloride	Nickelous Chloride	

You can reduce your production costs with 'Baker Analyzed' Reagents because (1) they are manufactured to exceedingly high standards of purity at no price premium to you, (2) they are consistently pure, consistently uniform, lot after lot, (3) Baker reagent purity regularly offers you the quality-plus demanded by the specialized processes and products of your industry, (4) the regular 'Baker Analyzed' Label defines a degree of purity so high that special "electronic grade" labeling is unnecessary.

As the electronics industry is able to define its needs more precisely, Baker will continue to provide material meeting the required specifications.

Listed at the left are some of the J. T. Baker high purity chemicals of particular importance to electronic manufacturers.

J.T.Baker CHEMICAL

J. T. Baker Chemical Co.
Phillipsburg, New Jersey

Circle No. 11 on Reader Service Card

GERMANIUM SLICING MACHINE

- Spindle speed infinitely variable from 5,000 to 20,000 RPM.
- Hydraulically operated table — variable feed rate from 1/64 inches per minute to four feet a minute.
- Rapid traverse return stroke six feet a minute.
- Precision cross feed control — increments variable from .011 to .075 inches — cross feed repeats within plus or minus .0005 inches.
- Will slice Germanium or Silicon slugs up to two inches diameter by six inches long.
- Rotating slug holder mechanism has speeds variable from five to one-hundred and twenty RPM.
- Automatic cycle operation — with Westinghouse CYPAK controls.
- Finger tip controls for ease of operation.

Manufacturers of precision surface grinders for production and toolroom needs

REID PRECISION SURFACE GRINDERS

REID BROTHERS COMPANY, INC. / 153A ELLIOTT ST. / BEVERLY, MASSACHUSETT

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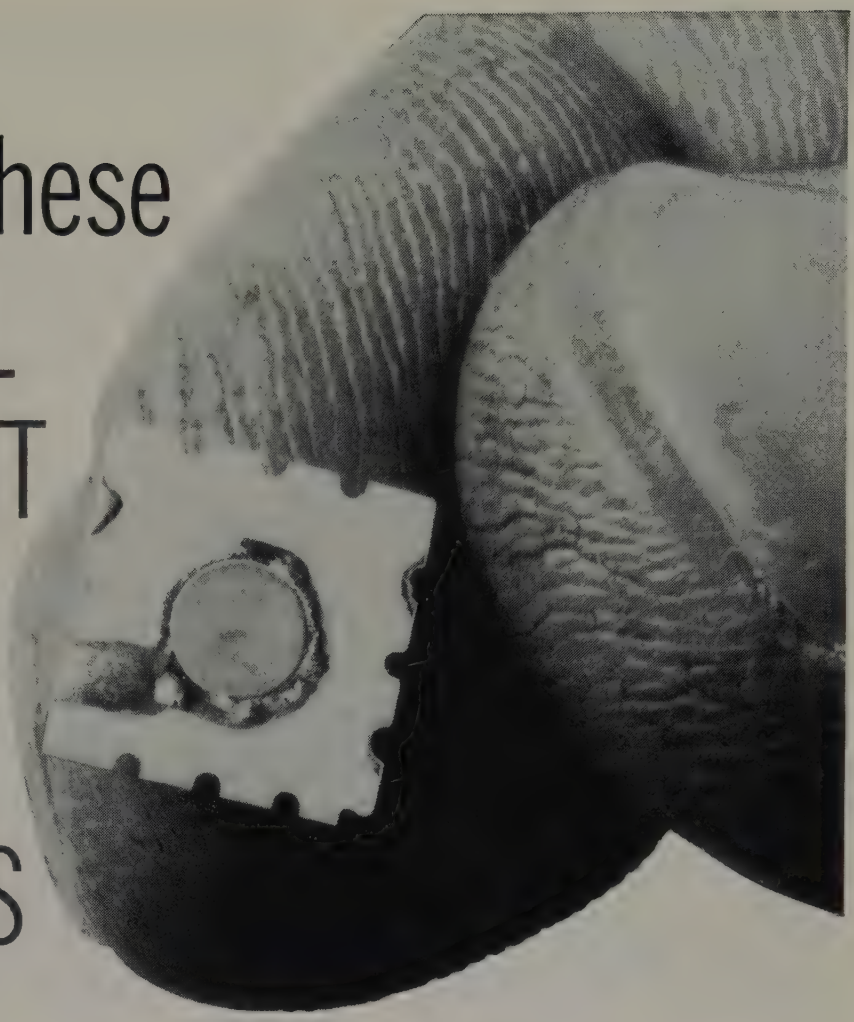
650 of these GENERAL INSTRUMENT MICRO-MODULE DIODES fit into a one inch cube



General Instrument Semiconductor Division developed this paper thin gold bonded germanium diode under the Signal Corps micro-module program and is now delivering in production quantities against government contracts. Actual size is .310" square and .016" thick. 350 of them weigh just an ounce!

And another step forward too: Semiconductors shrink further still as General Instrument engineering advances the art of micro-miniaturization to include even more sophisticated designs than micro-modules. Now the complete range of standard silicon and germanium diode types is available in these wafers and configurations – and in a wide variety of special packaging. We'll gladly supply engineering data sheets upon request.

Semiconductor Division

GENERAL INSTRUMENT CORPORATION

65 Gouverneur Street, Newark 4, N. J.

GENERAL INSTRUMENT CORPORATION INCLUDES F. W. SICKLES DIVISION, AUTOMATIC MANUFACTURING DIVISION, RADIO RECEPTOR CO., INC., MICAMOLD ELECTRONICS MANUFACTURING CORPORATION AND HARRIS TRANSDUCER CORPORATION (SUBSIDIARIES)

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Let KNAPIC *grow your* SILICON CRYSTALS *for you!*

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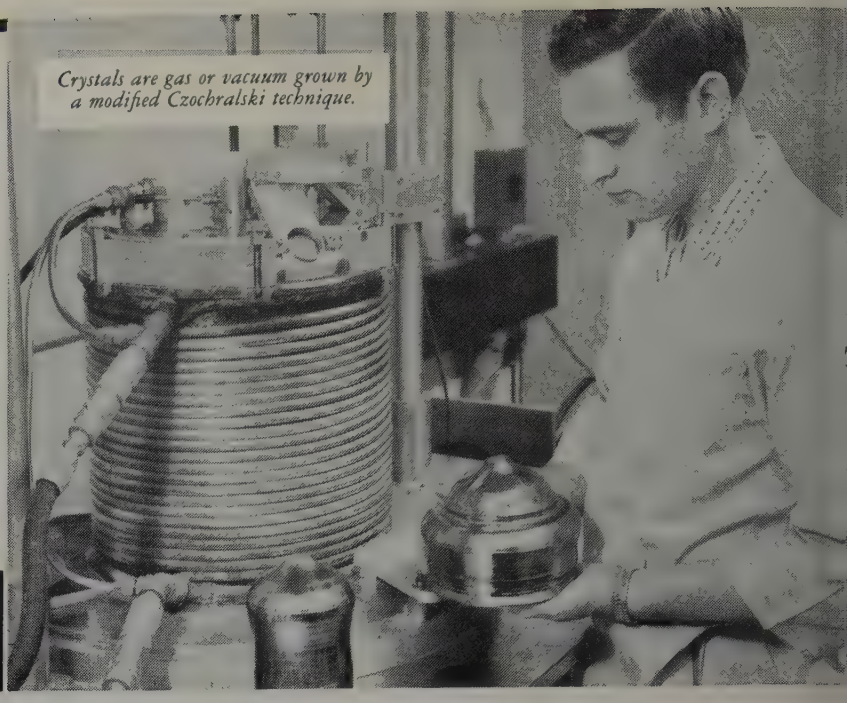

Crystals are gas or vacuum grown by a modified Czochralski technique.

SILICON AND GERMANIUM MONOCRYSTALS

For Semiconductor, Solar Cell and Infrared Devices

Major manufacturers of semiconductor devices have found that Knapic Electro-Physics, Inc. can provide production quantities of highest quality silicon and germanium monocrystals far quicker, more economically, and to much tighter specifications than they can produce themselves. Knapic Electro-Physics has specialized in the custom growing of silicon and germanium monocrystals. We have extensive experience in the growing of new materials to specification. Why not let us grow your crystals too?

Knapic monocrystalline silicon and germanium is available in evaluation and production quantities in all five of the following general grade categories —Zener, solar cell, transistor, diode and rectifier, and high voltage rectifier.

Dislocation density, Knapic silicon monocrystals. Crystal diameter 1/10" to 3/8"—None; 3/8" to 3/4"—less than 10 per sq. cm.; 3/4" to 1-1/4"—less than 100 per sq. cm.; 1-1/2" to 2" less than 1000 per sq. cm.

SPECIFICATIONS – Check These Advantages

- ☐ **Extremely** low dislocation densities.
- ☐ **Tight** horizontal and vertical resistivity tolerances. Resistivities available in controlled ranges .005 to 1000 ohm cm., N and P type.
- ☐ **Diameters** from .10" to 2". Wt. to 250 grams per crystal. Individual crystal lengths to 10".
- ☐ **Low Oxygen content** 1 x 10^{17} per cc., 1 x 10^{16} for special Knapic small diameter material.
- ☐ **Doping** subject to customer specification, usually boron for P type, phosphorus for N type.
- ☐ **Lifetimes:** 1 to 15 ohm cm.—over 50 microseconds; 15 to 100 ohm cm.—over 100 microseconds; 100 to 1000 ohm cm.—over 300 microseconds. Special Knapic small diameter material over 1000 microseconds.

Specification Sheets Available

TUNNEL (ESAKI) DIODE MATERIALS
RECOMMENDED SPECIFICATIONS

Material	Phosphorous Concentration x 10^{19} cm^{-3}	Specific Resitivity in ohm cm	Electron Mobility cm^2 $volt^{-1}$ sec^{-1}
SILICON	6.8	.00105	85
SILICON	11.0	.00078	81
SILICON	16.0	.00065	78
GERMANIUM	1.6	.00091	426
GERMANIUM	3.4	.00067	268

. . . Also manufacturer of large diameter silicon and germanium lenses and cut domes for infrared use

Knapic Electro-Physics, Inc.

936-938 Industrial Avenue, Palo Alto, California Phone: DAvenport 1-5544

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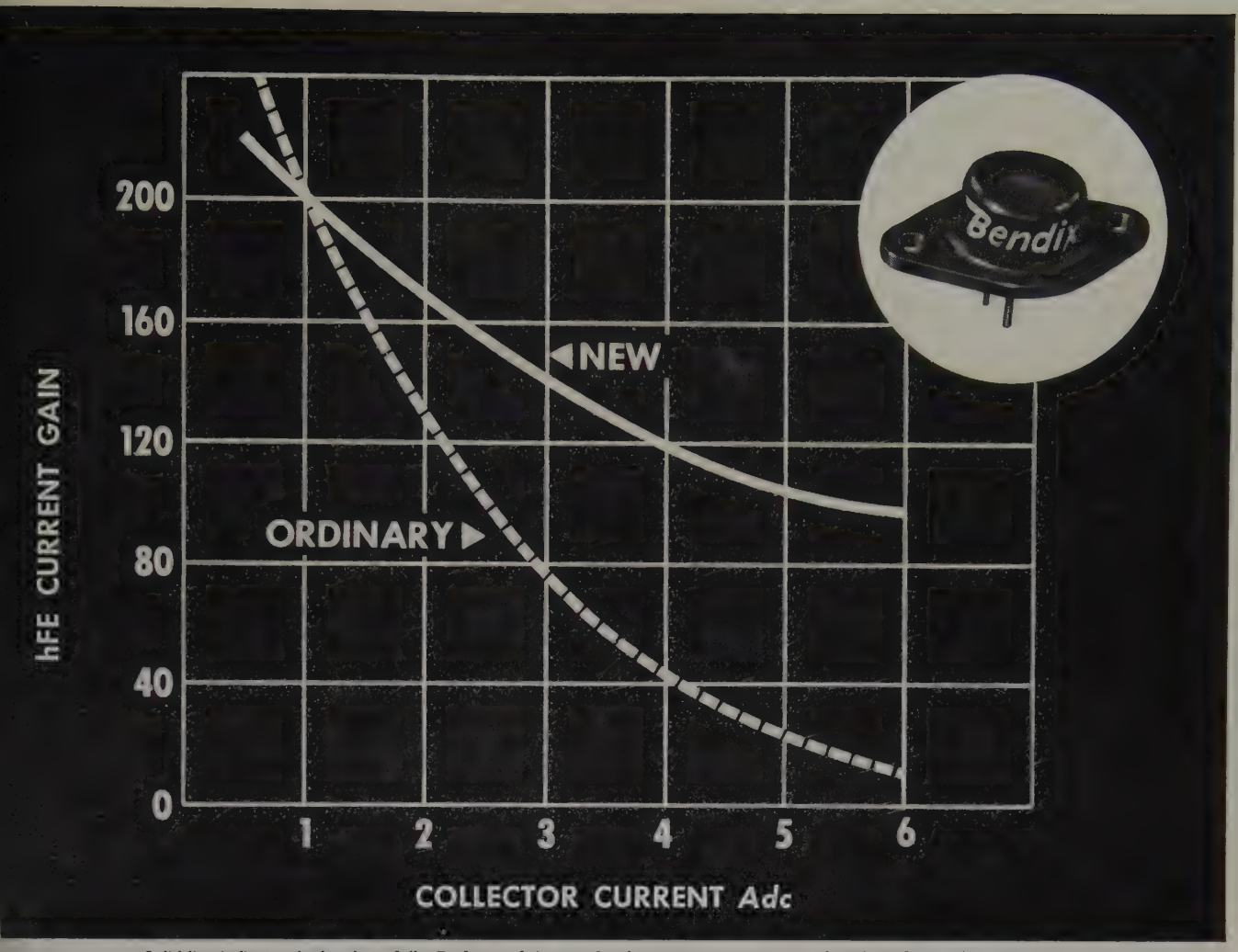

Solid line indicates the low beta fall-off of one of the new Bendix transistors as compared to that of an ordinary transistor.

NEW BENDIX HIGH GAIN INDUSTRIAL POWER TRANSISTORS OFFER FLATTEST BETA CURVE

Now available—a new series of power transistors with the flattest beta curve in the industry, made possible by an exclusive Bendix process. This new series has very high current gains—up to 200 at 3 Adc—and a 10-ampere peak current rating.

Featuring ten-amp performance at a five-amp price, the 2N1136, A, B; 2N1137, A, B; and 2N1138, A, B series provide:

LOW BETA FALL-OFF ——→ LESS DRIVE AND LESS DISTORTION
LOW SATURATION RESISTANCE ——→ GREATER CIRCUIT EFFICIENCY
VOLTAGE BREAKDOWN RATINGS ——→ ELIMINATION OF BURN-OUT
CURRENT GAIN MATCHING ——→ OPTIMUM CIRCUIT PERFORMANCE

Ideally suited for use in static converters and regulators, these power transistors also have numerous applications in relay replacements and drivers for relays, magnetic clutches, solenoids and other loads requiring high current. In addition, their extremely high current gain and excellent hFE linearity make them practical and efficient television vertical output amplifiers and hi-fi amplifiers.

Current Gain hFE at Ic = 3 Adc	Maximum Voltage Rating		
	Vcb 60 / Vce 40	Vcb 90 / Vce 70	Vcb 100 / Vce 80
50-100	2N1136	2N1136A	2N1136B
75-150	2N1137	2N1137A	2N1137B
100-200	2N1138	2N1138A	2N1138B

For complete information, contact SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, NEW JERSEY, or the nearest sales office.

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Midwest Sales Office: 4104 N. Harlem Avenue, Chicago 34, Illinois
New England Sales Office: 4 Lloyd Road, Tewksbury, Massachusetts
Export Sales Office:
Bendix International Division, 205 E. 42nd Street, New York 17, New York
Canadian Affiliate:
Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa 4, Ontario, Canada

SEMICONDUCTOR PRODUCTS
Red Bank Division
LONG BRANCH, N. J.

Bendix
AVIATION CORPORATION

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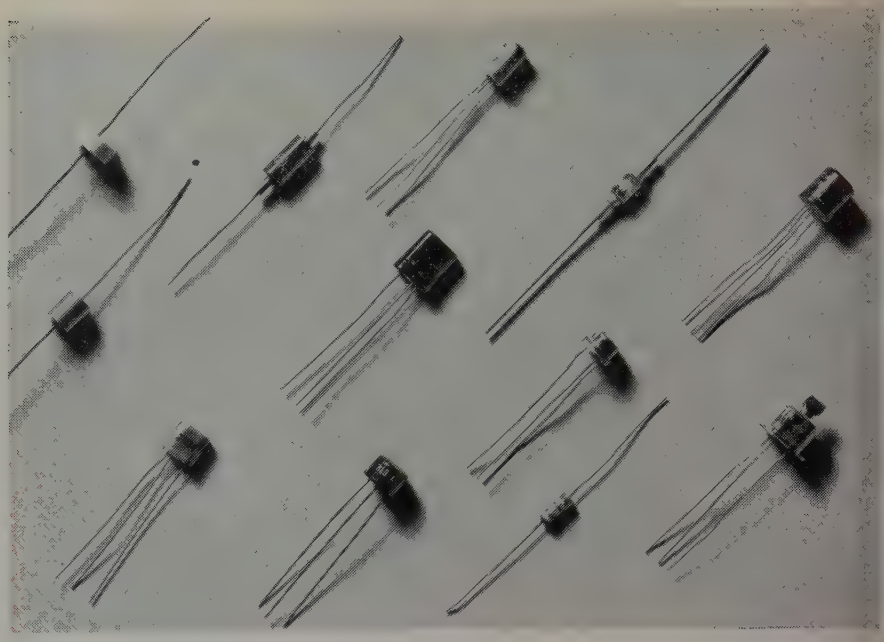
For etching

and washing

semiconductors . . .



B&A® "ELECTRONIC-GRADE" HYDROGEN PEROXIDE

IS THE PUREST AVAILABLE!

Special, new B&A "Electronic-Grade" H_2O_2, 30% and 30% "stabilized"—with its stringent pH specifications—reduces variations in rate of etch . . . cuts down rejects and improves quality control in the production of semiconductors.

To eliminate another variable in the use of hydrogen peroxide for semiconductor production, Baker & Adamson® has now added label specifications for the pH of "Electronic-Grade" H_2O_2, 30% and 30% "stabilized" (see box). The pH for hydrogen peroxide, 30%, is 2.5-3.5 . . . for 30% "stabilized," 3.0-3.5.

These tight specifications provide still better control and uniformity of peroxide than in the past and eliminate variations from lot to lot. This is still another example of B&A's continuing leadership in supplying production chemicals of the highest purity and quality for the electronic industry. B&A "Electronic-Grade" Hydrogen Peroxide, 30%, is readily available in 1 lb. plastic bottles and 30-gallon polyethylene-lined drums. "Electronic-Grade" Hydrogen Peroxide, 30% "stabilized," comes in 1 lb. or 5 lb. glass bottles and in the 30-gallon drums.

Remember . . . for the purest hydrogen peroxide available . . . as well as for the highest quality in other electronic chemicals . . . specify B&A!

Check these stringent specifications

HYDROGEN PEROXIDE, 30% ..... CODE 2774
H_2O_2 M.W. 34.02

MEETS A. C. S. SPECIFICATIONS

Assay (H_2O_2)	29.0-32.0%
pH	2.5-3.5

MAXIMUM LIMITS OF IMPURITIES

Residue after Evaporation	0.002%
Free Acid (As H_2SO_4)	0.003%
Chloride (Cl)	0.0005%
Nitrate (NO_3)	0.0005%
Phosphate (PO_4)	0.00025%
Sulfate (SO_4)	0.0005%
Ammonium (NH_4)	0.0005%
Heavy Metals (as Pb)	0.0001%
Iron (Fe)	0.00005%

HYDROGEN PEROXIDE, 30% ..... CODE 2775
"STABILIZED"
H_2O_2 M.W. 34.02

Assay (H_2O_2)	29.0-32.0%
pH	3.0-3.5

MAXIMUM LIMITS OF IMPURITIES

Residue after Evaporation	0.03%
Free Acid (as H_2SO_4)	0.005%
Chloride (Cl)	0.0005%
Phosphate (PO_4)	0.020%
Sulfate (SO_4)	0.001%
Heavy Metals (as Pb)	0.0001%
Iron (Fe)	0.00005%

HYDROGEN PEROXIDE, 3% SOLUTION . . . CODE 2773
H_2O_2 M.W. 34.02

Assay (H_2O_2)	3.0-3.5%

MAXIMUM LIMITS OF IMPURITIES

Residue after Evaporation	0.020%
Free Acid (as H_2SO_4)	0.010%
Chloride (Cl)	0.0005%
Nitrogen Compounds (as N)	0.005%
Phosphate (PO_4)	0.003%
Sulfate (SO_4)	0.005%
Arsenic (As)	0.00001%
Heavy Metals (as Pb)	0.0001%
Iron (Fe)	0.00005%
Preservative	0.035%

BAKER & ADAMSON®
"Electronic Grade" Chemicals

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N. Y.

Circle No. 16 on Reader Service Card

CA

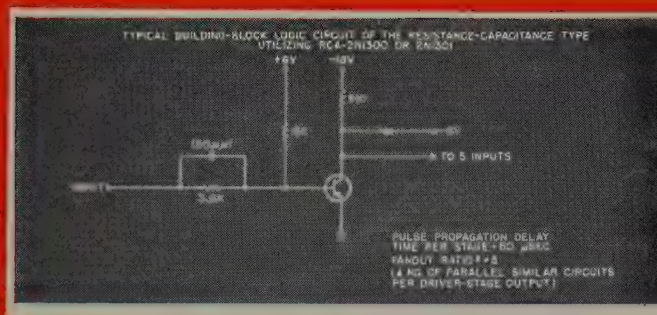
MESA

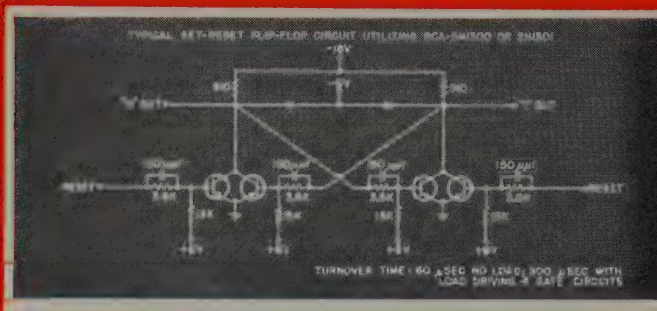
MPUTER TRANSISTORS

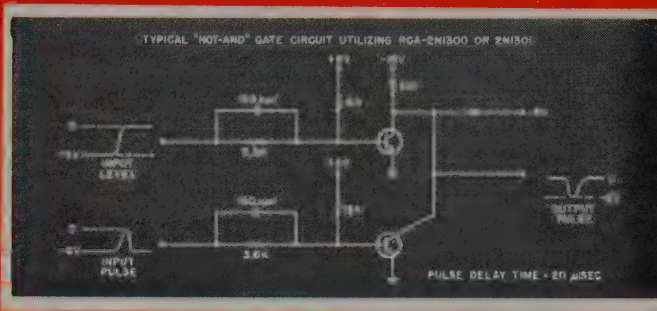
1300 · 2N1301

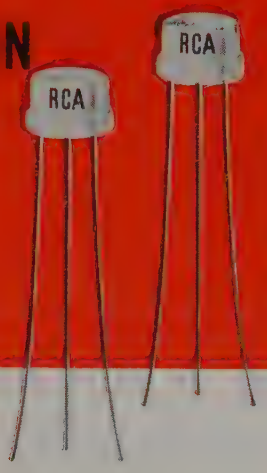
ture

GH POWER DISSIPATION
ST-SWITCHING TIMES
LOW COST


TYPICAL BUILDING-BLOCK LOGIC CIRCUIT OF THE RESISTANCE-CAPACITANCE TYPE UTILIZING RCA-2N1300 OR 2N1301
+6V
−12V
TO 5 INPUTS
PULSE PROPAGATION DELAY TIME PER STAGE = 80 μSEC
FANOUT RATIO = 5
(4 NO. OF PARALLEL SIMILAR CIRCUITS PER DRIVER-STAGE OUTPUT)







RCA TYPE	Maximum Ratings—Absolute-Maximum Values							Characteristics: Common-Emitter Circuit, Base Input—Ambient Temperature = 25°C		
	Collector-to-Base Volts	Collector-to-Emitter Volts	Emitter-to-Base Volts	Collector Ma.	Transistor Dissipation Milliwatts			Minimum DC Current Transfer Ratio		Gain-Bandwidth Product▲ Mc
					at 25°C	at 55°C	at 71°C	at collector ma = −10	at collector ma = −40	
2N1300	−13	−12	−1	−100	150	75	35	30	—	40
2N1301	−13	−12	−4	−100	150	75	35	30	40	60
collector ma = −10 and collector-to-emitter volts = −3										

A's Germanium P-N-P Mesa Transistors 2N1300 and 2N1301 combine -cost and quantity availability with these major benefits for designers witching circuits:

- gh power dissipation—150 milliwatts ximum at 25°C, 75 milliwatts maxi- um at 55°C
- t switching times—made possible by gh frequency response and low total red charge
- gged Mesa structure—with an ex- mely small base width to insure top rformance at high frequencies
- gh current transfer ratio—permits gh fanout ratios (number of paralleled nilar circuits per driver-stage output)
- high breakdown-voltage and punch-through voltage ratings—result of the diffusion process
- high current ratings—improves overall system speed
- especially well suited for use at pulse repetition rates up to 10 Mc
- rugged overall design—units have unusual capabilities to withstand sévere drop tests and electrical overloads
- electrical uniformity—a result of the diffused-junction process used by RCA in the manufacture of Mesa Transistors

Contact your RCA Field Representative for prices and delivery. For technical data, see your HB-10 Semiconductor Products Handbook, or write RCA Commercial Engineering, Section L-100-NN, Somerville, N. J.

RCA FIELD OFFICES

East: 744 Broad St., Newark, N. J. HUmboldt 5-3900

Northeast: 64 "A" Street, Needham Heights 94, Mass. Hillcrest 4-7200

East Central: 714 New Center Bldg., Detroit 2, Mich. TRinity 5-5600

Central: Suite 1154, Merchandise Mart Plaza, Chicago 54, Ill., WHitehall 4-2900

West: 6355 E. Washington Blvd., Los Angeles 22, Calif., RAymond 3-8361

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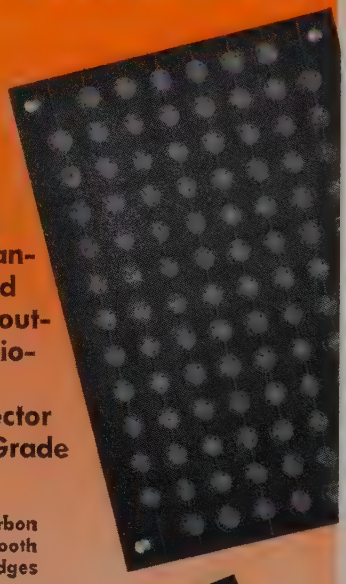
PURE CARBON

HI-PURITY... HARD-DENSE CARBON and GRAPHITE for

1. GLASSING BOATS
2. ALLOYING BOATS
3. CRUCIBLES
4. EMITTER and COLLECTOR WASHERS

- *PROVIDES OUTSTANDING OVEN LIFE*
- *RESISTS OXIDATION AND MECHANICAL EROSION*



The Pure Carbon Company has complete facilities for the precision manufacturing of all types of boats and fixtures in *Grade L-56 and other outstanding materials. We have also pioneered the manufacture of small, extremely accurate emitter and collector washers, header weights, etc., in **Grade P-1.

*The most widely used electro-graphite in the semi-conductor industry

**Molded-to-size carbon graphite with dense, smooth surfaces and chip-free edges

EMITTER and COLLECTOR WASHERS

Sectional view of typical configuration shown 20X size

Write for complete information and quotations

PURE CARBON COMPANY, INC.

449 HALL AVE. ST. MARYS, PENNSYLVANIA

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PERSONNEL NOTES

Robert E. Freund has been chosen to manage Fairchild Semiconductor Corporation's new diode facility in Marin County, California, and to head engineering there. He will maintain offices in their Palo Alto Research and Development Laboratory until the Marin Plant is ready for occupancy in January. A University of Pittsburgh graduate, he received his B.S. Degree in Physics in 1954. At that time he was awarded a graduate assistantship at Pitt and also became a Research Fellow with the Mellon Institute in Pittsburgh.

Robert W. Diamond has joined Solid State Products, Inc. in the capacity of Sales Manager. Mr. Diamond, an Electrical Engineering graduate of Northeastern University, has been associated with the semiconductor field for many years. He will be responsible for directing Solid State's expanding sales operations in the advanced PNPN semiconductor field.

J. E. Bradley, has been appointed production superintendent for Monsanto Chemical Company's ultra-pure silicon plant now under construction by the Inorganic Chemicals Division in St. Charles County, Mo., E. C. McCarthy, plant manager, announced recently. Mr. Bradley holds a BS degree in mechanical engineering from Lehigh University (1944). He served in the Special Engineering Detachment of the U. S. Army at Oak Ridge, Tenn., and Dayton, Ohio, before joining Monsanto in 1946.

Carl B. Fryklund has been appointed supervisor, regional applications engineering for Raytheon Company's Semiconductor Division. From his office in Franklin Park, Illinois, he will direct semiconductor applications engineering in the 22-state midwestern region and act as engineering liaison between field sales representatives and sales headquarters.

Donato R. Telesca has been named Vice President and General Manager of the International Metalloids, Inc., Toa Alta, Puerto Rico plant. International Metalloids, Inc., jointly owned by W. R. Grace & Company and Pechiney of Paris, France, is producing high purity densified silicon. Mr. Telesca, formerly associated with the Davison Chemical Company, Division of W. R. Grace in Baltimore, Maryland, holds a B.S. in Chemical Engineering from Massachusetts Institute of Technology and a B.S. in Business Administration with a major in management from Rutgers University. He is a member of the American Institute of Chemical Engineers.

Pacific Semiconductors, Inc., Culver City, a leading producer of semiconductor devices, announces the appointment of Frank Steinebrey, former PSI developmental engineer, as program director on an Air Force ultra high power transistor project.

Sydney Simon has been named Vice President and Director of Engineering of U. S. Transistor Corp., electronics manufacturing firm of Syosset, Long Island. Prior to this appointment Mr. Simon was President of Creative Electronics. He is an expert in design and consultant work and research on transistorized power supplies and high voltage power supplies, automated travelling wave tubes and high power transmitting tube test sets.

Appointment of Robert E. Murphy as Assistant Chief Engineer of LEL, Inc., Copiague, New York, designers and manufacturers of special purpose receiving equipment, has been announced by G. A Nuebling, General Manager.

Major General Louis Rumaggi (Ret.), U. S. Army Corps of Engineers, has joined Texas Instruments Incorporated as Manager, Central Services Section, in the Central Marketing Division, S. T. Harris, Vice President, Marketing, has announced. General Rumaggi comes to TI after a distinguished career of 37 years with the Army Engineers. At Texas Instruments, he will be responsible for office services, plant services, and new facilities. He will report to Vice President Harris.

Appointment of George A. Hildebrand as Administrator, Micromodule and Rectifier Sales, RCA Semiconductor and Materials Division, was announced recently by T. R. Hays, Manager, Sales Department. Mr. Hildebrand received his B. S. degree in Electrical Engineering from the University of Rhode Island.

Joseph D. Hurley has been named marketing manager for Rheem Semi-conductor Corporation, Mountain View, California, it was announced by Dr. E. M. Baldwin, vice president and general manager of the Rheem Manufacturing Company subsidiary.

The appointment of S. George Lawson to the newly created position of operations manager for the Semiconductor Division of Sylvania Electric Products Inc. has been announced by William J. Pietenpol, divisional Vice President and general manager.

The appointment of Cyril L. Fernquist as Chief Electro-Mechanical Design Engineer has been announced by Transistor Electronics Corporation, Minneapolis, a local firm specializing in electronic and computer components. Mr. Fernquist will be in charge of electro-mechanical design.

Dr. Joseph S. Smatko has joined Hoffman Laboratories Division, Hoffman Electronics Corporation, as a senior scientist in the Advanced Development Section, it was announced by Richard A. Maher, division vice president-engineering. Dr. Smatko, formerly associate professor and acting head of the Department of Chemical Engineering, University of Southern California, has been a leading consultant in the electro-chemical field for over 20 years.

The Board of Directors of The Narda Ultrasonics Corporation, Westbury, N. Y., announced recently that Paul M. Platzman who was Executive Vice President, is no longer associated with the firm. Dr. John C. McGregor, president, assumes full operating as well as policy direction of the company.

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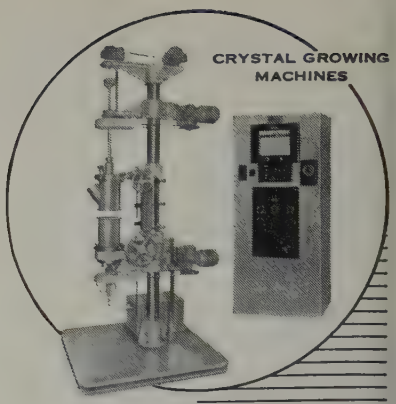

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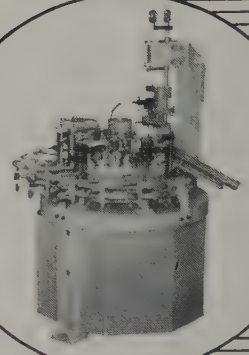
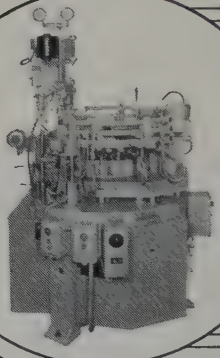


DIODE BODY CASE MACHINES



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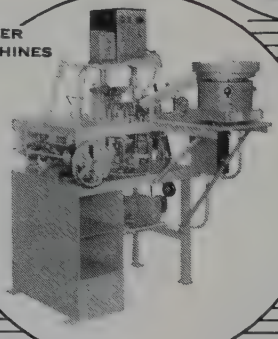
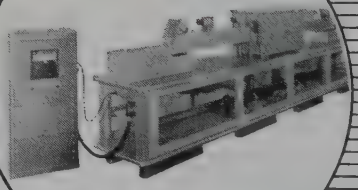


CRYSTAL MOUNTING MACHINES



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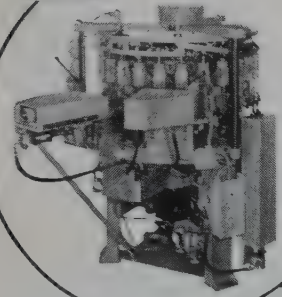

Circle No. 20 on Reader Service Card

SEASON'S GREETINGS

Editorial . . .

Hall Effect In Plasma

The electrical phenomena which take place in plasma are of considerable interest for many branches of physics; in particular they have been used with advantage for the interpretation of many phenomena in semiconductors.

An effect which may have very important applications for the generation of power is the production of electromotive force by Hall effect. If a stream of highly ionized plasma is moving at high speed through a space where a transversal magnetic field distribution exists, forces of magnitude $q(\bar{u} \times \bar{B})$ are applied to each charged particle with the result that the positive ions and the electrons drift to opposite sides of the stream. If two probes are placed opposite to one another in the stream and perpendicularly to the directions of u and of B, an electrostatic field is built up which opposes the above drift. In equilibrium the difference of potential of the probes is $V = uBd$, if d is their separation.

The utilization of this effect for power supply applications requires that several difficult problems be solved. First of all there are problems connected with the generation and the maintenance of the plasma stream; this generally has extremely high temperature, of the order of 10,000°K. Second, the efficiency of the device depends on the volume resistivity of the plasma.

Some experiments have been performed recently at the University of Oklahoma (Sekuntala, Clotfelter, Edwards and Fowler—Jour,Appl.Phys.-Nov. 1959) using an hydrogen plasma in a glass tube of diameter 1.5 cm. The tube was divided in two sections, arranged collinearly and consisting respectively of a heating chamber and of an expansion chamber. When a shock discharge is produced in the heating section, a cloud of highly ionized gas emerges into the expansion chamber, where a transversal magnetic field is produced by means of an electromagnet with parallel pole faces of 9 cm diameter, designed to produce a maximum field of 1 *Wb*/sq.m. Probes consisting of copper disks were used to pick up the Hall voltage. As an example, using gas pressure of 2.8 mm and an appropriate discharge, peak velocities of the order of 1.6×10^6 cm/sec were obtained, with a corresponding Hall electromotive force of the order of 7 volts. The internal resistance of the device was found to be high and to vary with the distance from the heating chamber. As an example, a resistivity of the order of 10 ohm-cm was measured for a gas having temperature between 7000 and 10,000°K. Such high value indicates that the motion of charges in the space between the probes is controlled predominantly by the ionic charges rather than by the electrons.

Correction

We wish to call attention to a correction in the article "Frequency Multiplication and Division By Semiconductor Diodes At Microwave Frequencies" by D. Leenov and A. Uhlir, Jr., in the October 1959 issue. On page 26 the fourth line after Equation 1, $n^{1/2}$ should be: $1/n^2$. In the fifth line after Equation 1, $n^{1/4}$ should be $1/n^4$.

Samuel L. Marshall

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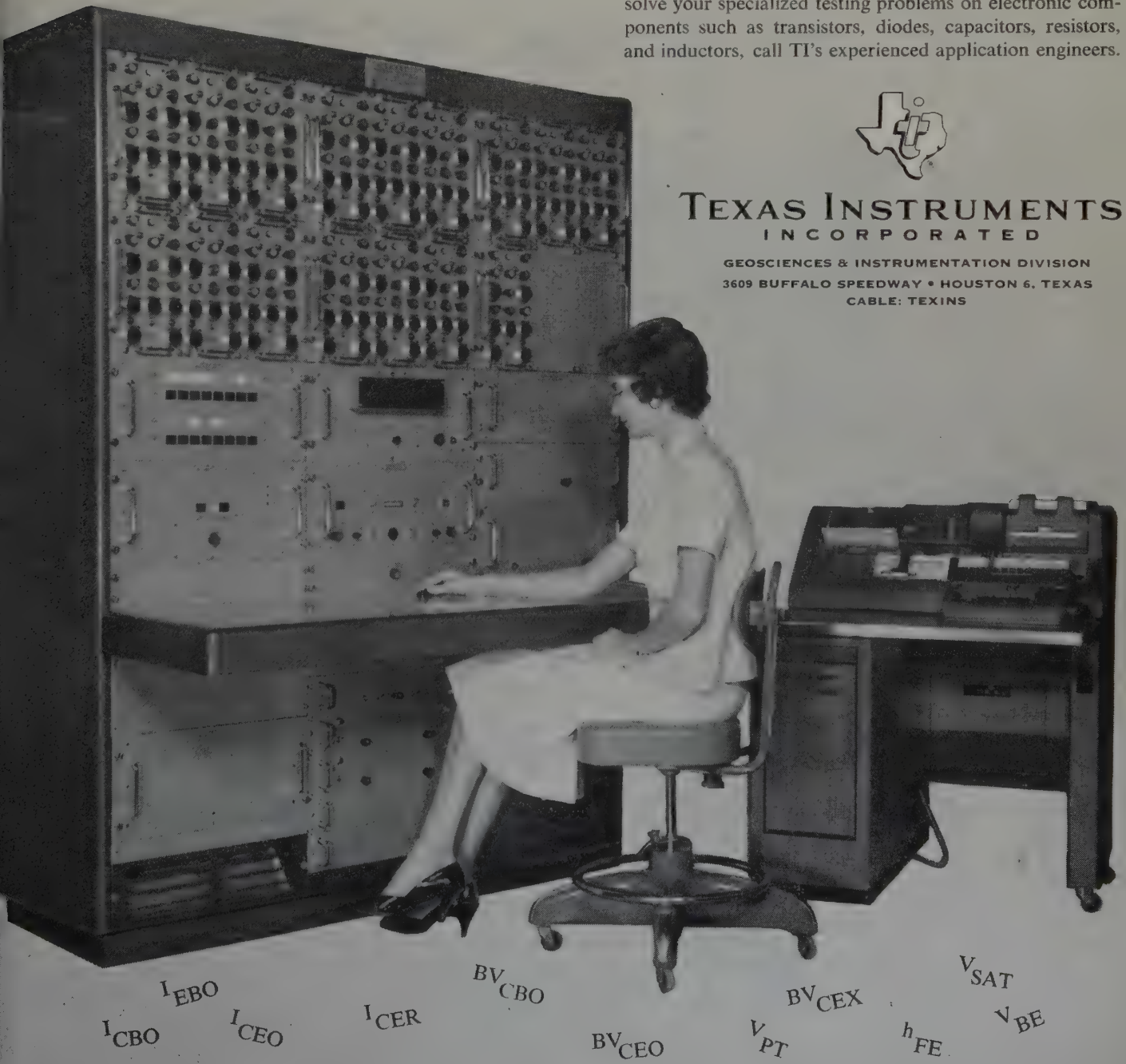

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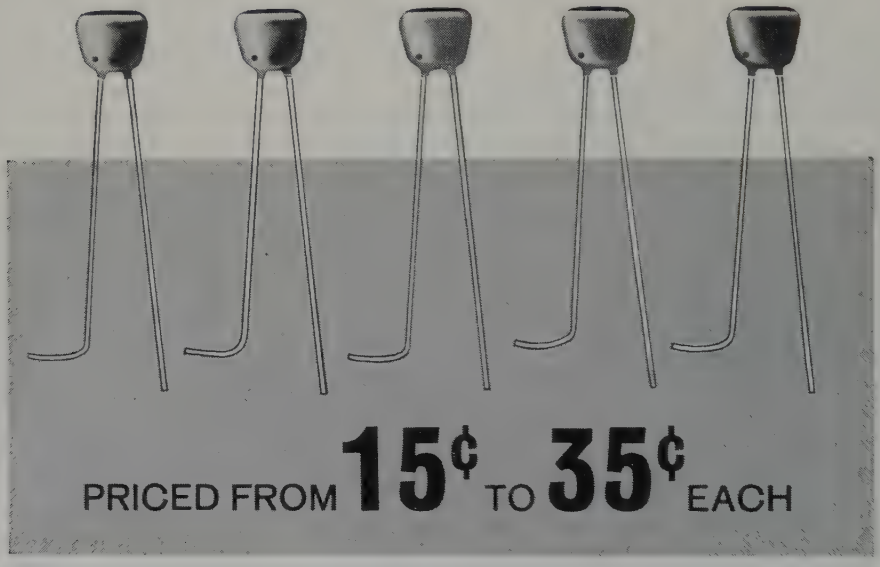

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14″ Direct View Transistorized Television Receiver

C. R. GRAY*

This paper describes a completely transistorized, battery operated 14″ direct view television receiver. This receiver was designed to illustrate the feasibility of transistorized television and is not intended to be a preproduction model. The receiver uses 23, nonselected, commercially available, transistors; 12 diodes; and a 14″ 70°, 1 1/8″ neck cathode ray tube. The total power consumption is 25 watts. Performance measurements included herein indicate that the overall sensitivity and picture quality are comparable with those of many commercially available tube receivers. Field tests have indicated that the set operates well with varying signal levels and it is concluded that large screen transistorized portables may be designed and mass produced using commercially available transistors.

THE RECEIVER DESCRIBED herein has been designed using conventional transistor circuits and little engineering effort has been spent in minimizing the number of components. It has, however, been designed to operate with the normal parameter variations encountered in the specified transistors. Complete coil information is provided in this article.

The picture tube operates at 11,000 volts anode voltage with a 100 μ*a* load. The receiver is powered with two 6 volt, 5 a.h. rechargeable batteries forming a 12 volt supply.

High Frequency Transistors

Before a commercially acceptable transistorized television receiver could be built, it was necessary that reliable low cost high frequency transistors be developed for the tuner and *if* stages. It was also imperative that these transistors be interchangeable in their respective sockets in order that production quantities of TV receivers could be built with a minimum of adjustments on the line.

The development of the Fast Automatic Transfer (*FAT*) Line at Lansdale has made possible the manufacture of reliable high frequency transistors at low cost. To make them useful to the TV market, test sets and specifications have been developed for the *rf* amplifier, mixer, oscillator and video *if* transistors. By functionally testing these units in circuits similar to those in TV receivers, consistent operation and interchangeability from set to set is assured.

Circuit Description

Tuner

The tuner for this receiver, made by modifying a turret type tube tuner[1], typically delivers 15-18 *db* gain with a 12-14 *db* noise figure at Channel 13. A single channel circuit diagram of this tuner is shown in *Fig. 1* and typical gain and noise figure measurements are shown in *Fig. 2*. The tuner uses a common-emitter, fixed-neutralized, *rf* stage and employs base injection of the local oscillator signal into the mixer.

It has been found that emitter injection provides

* Lansdale Tube Co., Lansdale, Pa.

[1]A Standard Coil Model GG-4200 *vhf* tuner was used. Most of the coils are the same as the ones used in the tube version.

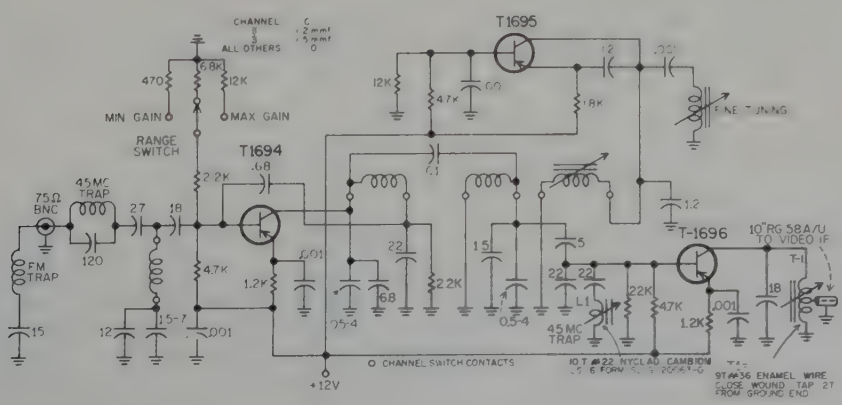

Fig. 1—Turret tuner.

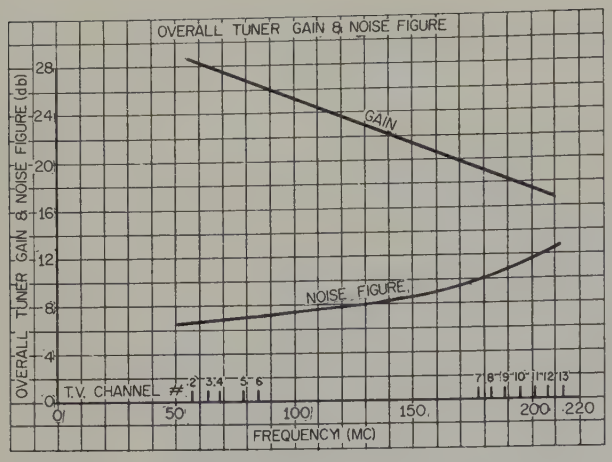

Fig. 2—Gain and Noise Figure *vs.* Frequency.

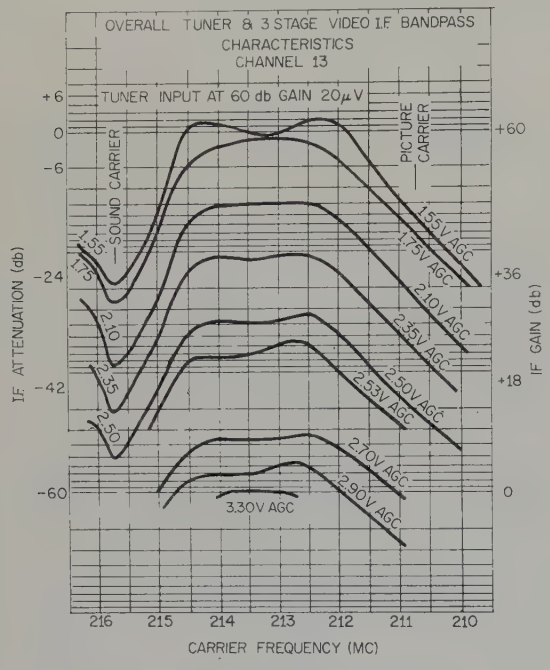

Fig. 3—Overall tuner and video *i.f.* bandpass characteristic.

slightly higher mixed conversion gains; however, it is difficult in a turret type tuner to use emitter injection because of unwanted coupling through the coils. Our experience indicates that incremental type tuners are more effective when using emitter injection. It will also be noticed that there is a 45 *mc* series trap to ground on the base of the mixer. This substantially increases conversion gain by eliminating 45 *mc* degeneration in the mixer.

The local oscillator transistor has been designed and specified to deliver a minimum of 1.5 *mw* of power at 257 *mc*. The mixer has been designed and specified to deliver high conversion gain with a minimum of 1 *mw* of power injected by the oscillator.

Video I.F.

The video *if* consists of a 3 stage amplifier which is essentially broad band except for the input circuit. A schematic of the 3 stage amplifier is shown in *Fig. 4* and typical bandpass characteristics are shown in *Fig. 3*. The amplifier provides between 60 and 65 *db* of power gain at 45 *mc* and sufficient *agc* control to reduce the overall gain of the amplifier below zero.

A four stage *if* amplifier has also been built with overall gains of 70 to 80 *db*. The four stage strip uses two forward *agc*[2] and one reverse *agc*[2] stage. The three stage *if* amplifier uses forward *agc* in the first two stages only.

Forward and Reverse AGC

Forward *agc* is a method for which *MADT* type transistors are ideally suited. It is accomplished by placing a bypassed 2200 ohm resistor in the cold end of the collector transformer. *AGC* action is obtained by increasing the current in the transistor, which causes the collector to emitter voltage to drop, thereby reducing the gain.

Forward *agc* has the advantage over reverse *agc* in that it has much better overload characteristics as shown in *Fig. 5*. This curve is for the 4 stage *if* strip. A similar condition exists in the 3 stage amplifier. It is therefore particularly well suited for stages where large signals are encountered such as the *rf* amplifier and first *if* stages. Forward *agc* results in slightly higher center frequency shifts with *agc* because of the change in collector capacitance with voltage, but in broad band stages the shift in frequency is relatively unimportant.

Reverse AGC

Reverse *agc* is accomplished in the usual manner

[2]For a complete explanation of the mechanism of forward and reverse *agc* refer to Lansdale Tube Co. Application Lab Report #575 by C. D. Simmons.

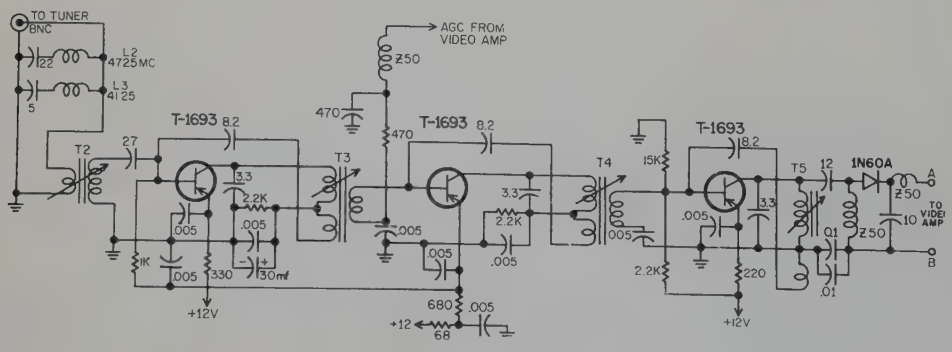

Fig. 4—Three stage 45 *mc* *i.f.* amplifier.

COIL DATA			
IND.	FORM	PRIM.	SEC. NEUT.
T-2	SICKLES	7T#26	2T#26 —
T-3	SICKLES	16T#26	3T#26 2T#26
T-4	SICKLES	16T#26	3T#26 2T#26
T-5	SICKLES	16T#26	2T#26 2T#26
L-2	CTCL6	7T#26	
L-3	CTCL6	22T#28	

SICKLES FORM 247-5401-1
SICKLES CORE 218-5244-3

by reducing the collector current and thereby reducing the stage gain. Reverse *agc* does not provide as good overload performance but results in less frequency shift with *agc*. It should be used in stages where frequency shift is important.

The 60 *db* gain of the *if* strip plus the 15 *db* gain of the tuner at Channel 13 provides at least 75 *db* power gain from antenna to the second detector. With the 4 stage *if* strip, the gain to the second detector is about 90 *db*. The receiver sensitivity, therefore, is comparable both in gain and noise figure with that of many commercially available tube sets. Typical receiver sensitivity measurements are shown in *Fig. 6*. The second detector circuit uses a conventional series diode and normally delivers, under *agc* control, between .4 and .7 *v* peak to peak video to the base of the video driver.

Video Driver

The video driver is an *MADT* transistor that is designed primarily for a high f_T. An emitter follower is used to provide a high input impedance to avoid loading the second detector and also to provide low output impedance to drive the video output stages. In the collector of the video driver there is a 1.8 K unbypassed resistor from which the sound is taken and a 4.7 K bypassed resistor for the *agc* takeoff. It will be noted in *Fig. 7* that the output from the video detector is *d-c* coupled to the base of the driver, thus the video driver also acts as an *agc* amplifier. The swing in voltage across the 4.7 K resistor is between 2 and 3 *v* and provides sufficient *agc* voltage for the *if* strip. The video driver transistor is operated from a +24 volt supply which is taken from the flyback transformer. It was necessary that a positive supply be used in this application in order that the polarity of the *agc* voltage be proper and that there be approximately a +10 volt reference for the *agc* swing.

Video Output

The video output consists of two transistors stacked to divide the voltage (*Fig. 7*). They consist of a common emitter first stage and a common base voltage

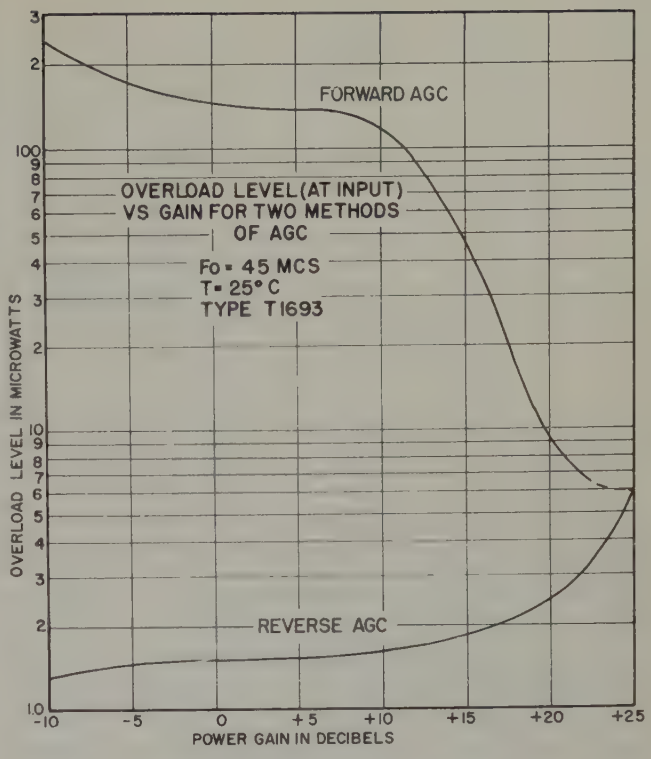

Fig. 5—Overload at input *vs.* Gain.

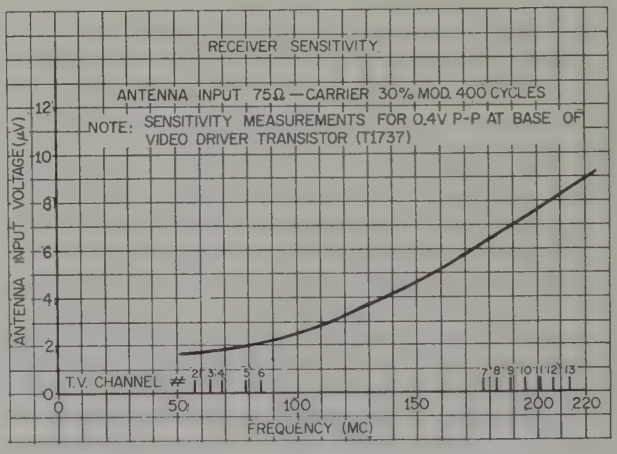
RECEIVER SENSITIVITY
ANTENNA INPUT 75Ω — CARRIER 30% MOD. 400 CYCLES
NOTE: SENSITIVITY MEASUREMENTS FOR 0.4V P-P AT BASE OF VIDEO DRIVER TRANSISTOR (T1737)
ANTENNA INPUT VOLTAGE (μV)
T.V. CHANNEL #
FREQUENCY (MC)

Fig. 6—Sensitivity *vs.* Frequency.

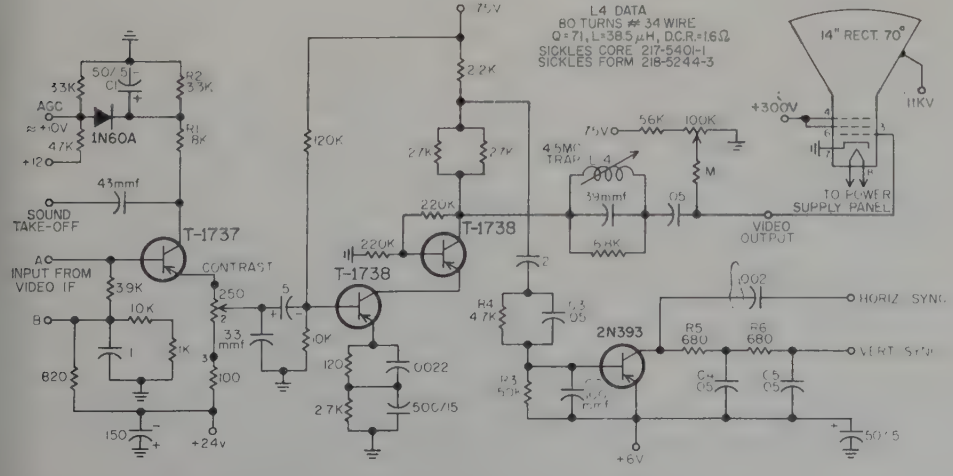

Fig. 7—Video amplifier and separator circuitry.

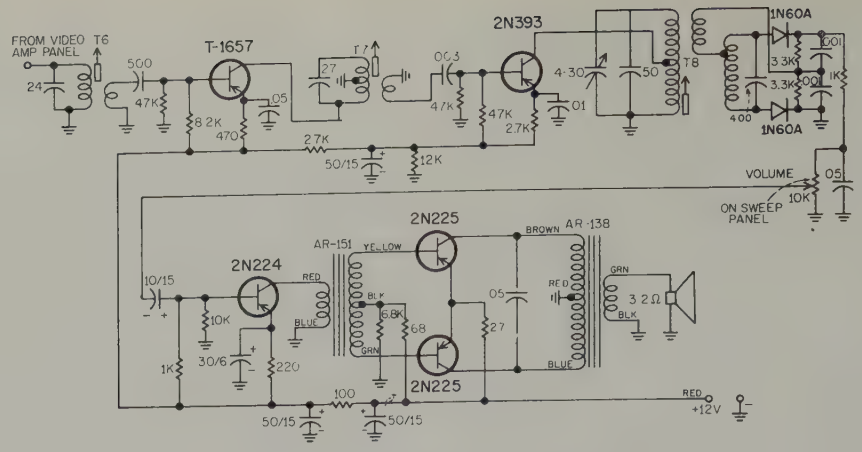

Fig. 8—Sound *i.f.*, limiter, discriminator, and audio stages.

doubler second stage. The total overall voltage gain from the base of the video driver to the grid of the cathode ray tube is 80. This provides a peak to peak signal of 48 *v* to grid drive the cathode ray tube with 0.6 *v* input from the second detector. A 48 *v* signal on this cathode ray tube produces a picture with reasonable contrast and one which under normal viewing conditions is comparable to that of a tube receiver. The maximum video signal available from the output stage is 60 *v pp*; however, if the input voltage to the video driver exceeds .7 *v* the sync tips turn off the video driver transistor resulting in sound buzz. The video amplifier has been designed to have a flat response to 3½ *mc* and to be down 3 *db* at 4 *mc*. The shunt sound trap attenuates the gain at 4.5 *mc* to a point where there is no visible sound beat in the picture.

Sync Separator

An *MAT* transistor is used in the sync separator circuit as shown in *Fig.* 7. This transistor makes an especially good sync separator because of its high beta and good switching properties. The transistor is operated grounded-emitter and the stage is self-biased by the *RC* combination to ground in the base of the transistor. The video signal is *a-c* coupled from a split video amplifier load resistor to provide about 4 *v* peak to peak video at the base of the sync separator. It is coupled through a large 2 *mf* capacitor and through an *RC* combination which provides both decoupling and improved vertical sync stability.

The horizontal sync signal is *a-c* coupled directly from the collector of the sync separator to the horizontal phase comparator network. The vertical signal is coupled through a two stage vertical integrator to an auxiliary winding on the vertical blocking oscillator transformer. The auxiliary winding is necessary to produce a phase inversion of the integrated vertical sync signal to trigger the oscillator.

Sound System

As noted earlier, the sound take off is from the collector of the video driver transistor. The sound signal is *a-c* coupled to a 4.5 *mc* tuned circuit at the base of the sound *if.* (*Fig. 8*). The T1657 sound *if* transistor is an *MADT* which is designed for use in this frequency range. It typically provides 35 *db* of gain at 4.5 *mc* with a bandwidth of about 300 *kc*. It is fixed neutralized from the secondary of the coupling transformer.

The limiter is an *MAT* transistor which provides good limiting over the range of signals normally encountered. The output of the limiter is transformer coupled to a conventional *fm* discriminator network. The de-emphasis network results in approximately 5 *db* loss and is followed by a 2N224 audio driver and a push pull output using 2N225 transistors. The entire sound system as shown in *Fig. 8* provides an overall gain of approximately 70-80 *db* which may be broken down as follows: *if*, 35 *db*; limiter, 20 *db*; detector, —35 *db*; de-emphasis, —5 *db*; and audio, 60 *db*. The maximum audio output is approximately 200 *mw*. Complete coil information for the sound circuit is given in *Fig. 9*.

Vertical Sweep Circuit

The vertical sweep circuit as shown in *Fig. 10* consists of a 2N223 vertical blocking oscillator followed by a 2N223 emitter follower driver and a T1337 vertical output unit.

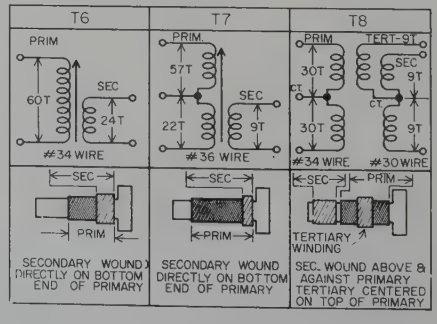

Fig. 9—Coil details for sound circuits. All coils wound on Sickles coil Forms 217-5401-1 (long) with 218-5244-3 cores. (2 cores in T-8)

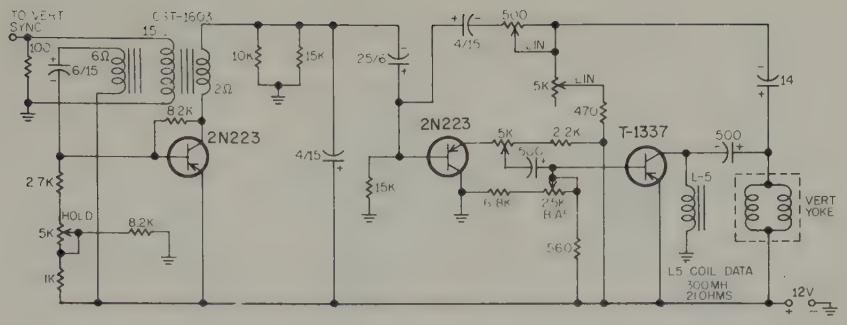

Fig. 10—Vertical oscillator circuit.

The blocking oscillator is a conventional circuit and the emitter follower has been used to prevent loading of the oscillator and also to provide a low output impedance for driving the output transistor. It is necessary to provide bias adjustment for the output stage in this particular circuit to accommodate large ranges of beta in the T1337 output transistor. The T1337 is a power transistor originally designed as a power switch. It features high beta and good beta linearity which are the prime requirements for good vertical linearity in a Class A vertical output circuit such as the one shown here. The *d-c* for this transistor is supplied through a 60 cycle choke to the collector and the 9 *mh* yoke is parallel connected and *a-c* coupled from the collector. The linearity network differentiates the waveform from the collector and then feeds it through a variable resistor and capacitor to the input of the vertical driver transistor. The combination of these two linearity controls and the use of variable bias makes it possible to deliver a 500-600 *ma* peak to peak linear sawtooth signal to the vertical yoke using a wide range of vertical output transistors. The linearity in this circuit is comparable with that of conventional tube receivers.

Horizontal Sweep Circuit

The horizontal drive circuit is shown in *Fig. 11*. It consists of an *SBT* horizontal oscillator, a 2N224 horizontal buffer and a T1337 driver. The *SBT* makes an excellent horizontal oscillator with good temperature stability over the range of temperatures normally encountered in a receiver (25-55°C). It is limited, however, in that it must be operated from a 6 *v* supply because of its low punch through rating. For this reason, the supply voltage to the horizontal oscillator has been dropped from 12 *v* to approximately 6 *v*. A low impedance phase comparator network further adds to the temperature stability of the horizontal oscillator and a flywheel circuit in the base of the oscillator provides positive triggering action. The buffer transistor serves to isolate the oscillator from the output stages and also provides sufficient power for driving the T1337 driver.

We have investigated two modes of operating the driver transistor. The first of these consisted of using the yoke action of the driver output transformer and generating a flyback pulse similar to the operation of the output stage. This was accomplished by maintaining the transistor in saturation for approximately 50 μsec and then turning it off for about 13 μsec. This produces a negative half sine wave of about 40 *v* amplitude at the collector of this transistor. This pulse was then transformer coupled and inverted to the base of the output transistors through a transformer having two identical bifilar secondary windings. In this circuit a 2N352 was used as the driver with good performance except that the total current drain was high. The circuit was therefore, redesigned using a

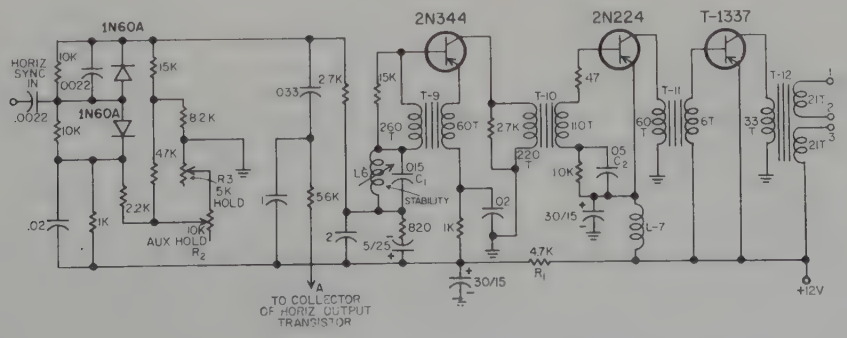

Fig. 11—Horizontal drive circuit.

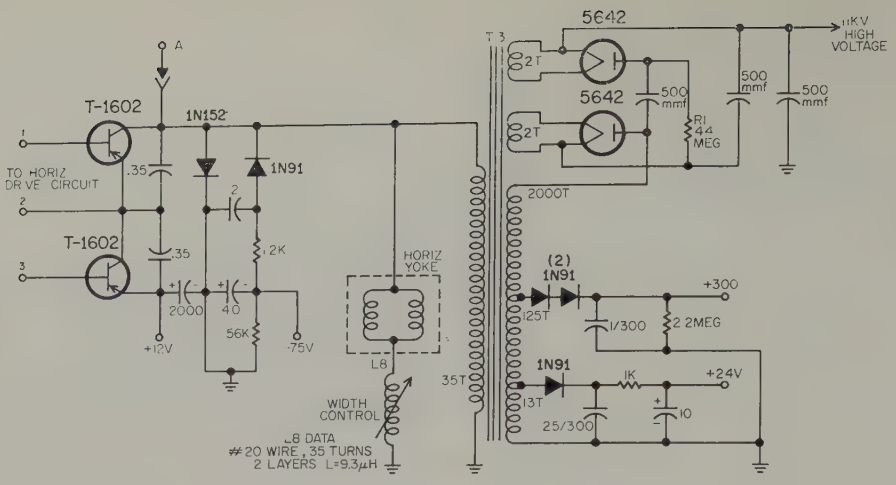

Fig. 12—Horizontal output and high voltage circuits.

T1337 as a pulse amplifier. This circuit, with properly designed transformers resulted in considerable power saving over the previous circuit and is the one currently being used. It is shown in *Fig. 11.*

The pulse from the collector of the T1337 is transformer coupled to the base of the two T1602 output transistors with a transformer having two identical bifilar secondary windings. The two output transistors have been mounted in series so that the 100 volt flyback pulse from the yoke is divided across the transistors. The T1602 is an auto radio type power transistor with a 55 volt diode breakdown rating. The horizontal output stage is shown in *Fig. 12.*

The horizontal output circuit operates as a flyback circuit. The two transistors are turned on in saturation by the averaging of a positive pulse on the base. The averaging of the base pulse is shown in *Fig. 13* and explained as follows: If the output transistors had a constant conducting input impedance the base pulse would average such that the area above and below the 0 reference line in the above sketch would be equal. For the transistor to saturate, the pulse amplitude and width must be such that the average base voltage between pulses is more negative than that required for saturation. While this analogy is somewhat inaccurate because the input impedance decreases with increasing collector and base current the general principle still applies.

For efficient operation of the driver stage the pulse amplitude at the output transistor base must be just high enough to maintain the output transistor in saturation for the complete conduction time. Any increase in the base pulse amplitude will result in a more negative base voltage. This increases the power required from the driver, and also the time required to switch the transistor out of saturation.

For efficient operation of the output stage the time required to switch the transistor out of saturation must be short. This may be reduced by applying a larger positive pulse to the base. In a practical design it is necessary that a compromise be reached between these two conflicting requirements by studying the total power supplied to the driver and the output stage. Considerable effort has been spent in this receiver to minimize the total horizontal power requirements. Complete coil data for the horizontal circuit is given in Table I.

The 45 μ*h* horizontal yoke is connected in series with a small width control choke and the two are then connected in parallel with the primary of the flyback transformer. It will be noted that capacitance has been added between the collector and emitter of each of the output transistors. This capacitance is provided so that the horizontal circuit will ring at approximately 50 *kc* during retrace time. The capacitance has been divided between collector and emitter

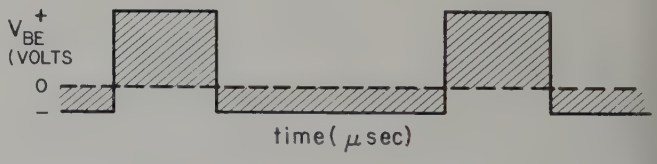

Fig. 13—Averaging the horizontal output base pulse.

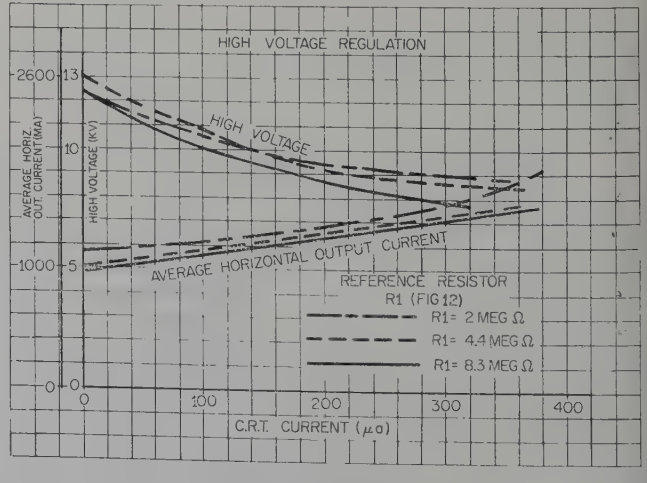

Fig. 14—High voltage regulation.

TABLE I. Horizontal Drive Circuit Coil And Transformer Data

Part No.	Wire Size	Pri Turns	Sec Turns	Winding Method	Coil Form
L-6	3.8–7.0 mh	Q-50 at 250 kc		Universal Wound	Sickles Form 217-5401-1 Core 218-5244-3
L-7	22	20 (2.5 μ h)		Two Layers Over Entire Form	Form-Air Core Fibre I.D. 8 mm Length 8mm
L-8	20	35	2 Layers	L = 9.3 μ h	$1\frac{5}{8}$" x $\frac{3}{8}$" O.D. Fiber Form $\frac{5}{8}$" x $\frac{5}{16}$" Dia. Ferrite Core
T-9	43	260	60	Sec Wound On Top of Pri	Elna Lab., Inc. 273P236-E1-3B3
T-10	38	220	110	Same as T-9	Same as T-9
T-11	26	60	6	Same as T-9	Same as T-9
T-12	24	33	21 x 21	Secondaries Bifilar Wound On Top of Primary	Elna Lab., Inc. 380P315E1-3B2
T-13	38 Nylon	# 35 26	2000	Wound on Universal Coil Winder Model 14-B [1] Weights 5H 2W; Sec I.D. $\frac{11}{16}$; Pri I.D. $\frac{5}{8}$; Gear Ratio 119/40; Gainer 0.9; Cam $\frac{1}{8}$	
Core: Stackrole Carbon AP11-417 Item 2. Form $\frac{5}{8}$ Fiber Tube.					

of each stage rather than a single capacitor across the yoke to help insure that the flyback voltage is divided equally across the two transistors. A 1N152 damper diode has been provided to serve as a damper at the end of the retrace time.

High Voltage and Auxiliary Supply Circuit

The high voltage circuit and auxiliary supply voltages are shown in *Fig. 12*. These include a +24 *v* supply for the video driver transistor, a —75 *v* supply for the video output transistors, and a +300 *v* supply for the G_2 voltage of the cathode ray tube.

The high voltage circuit uses a flyback transformer and a voltage doubler. The secondary of the transformer rings at approximately the third harmonic of the flyback frequency, i.e., 150 *kc*. At this point the efficiency of the transformer reaches maximum as does the magnitude of the high voltage. The high voltage is obtained with a conventional doubler circuit using 5642 high voltage miniature diodes whose filament power is supplied by two turns around the transformer core. The regulation of the high voltage supply is not as good as that of a tube receiver but does not appear objectionable. Improved regulation may be obtained by reducing the size of the bleeder resistance in the doubler circuit; however, increased regulation is obtained at the expense of added current in the output stage. *Fig. 14* shows a plot of High Voltage *vs.* Bleeder Resistance and *crt* current. The typical *crt* operating current in this receiver is 50 — 75 μa. The 24 *v* and 300 *v* auxiliary supplies are obtained from taps on the high voltage transformer through conventional filter circuits. The —75 *v* supply is taken directly from the collector of the output transistor by rectifying and filtering the negative flyback pulse.

Cathode Ray Tube

The cathode ray tube used in this receiver is an aluminized 70°, 14" rectangular narrow neck tube having a uniquely designed electrostatically focused gun with a 30 volt grid cutoff. It typically delivers 300-400 μa zero bias current and uses a 6 volt 145 *ma* heater.

In addition to this tube a high g_m tube has been designed for transistorized TV application and it is planned that this receiver will be modified to include

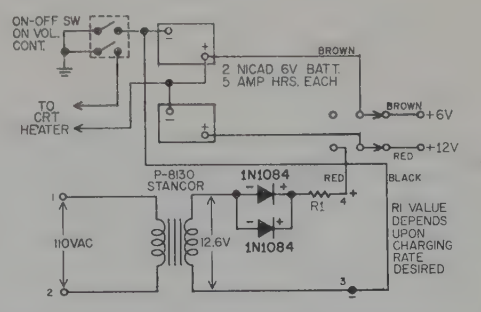

Fig. 15—Power supply and battery charger.

it in the near future. This tube has a 30 volt cathode cutoff and delivers 500-600 μa peak current with 30 volts of cathode drive. It requires 50 volts for G2 and also has a 6 volt 145 ma heater.

In addition to the heaters used in these tubes, developmental 10 and 12 volt, 1 watt heaters have been designed and built. They are not commercially available at the present time.

Yoke

The yoke used for this receiver was designed by F. W. Sickles Division, General Instrument Corporation, Chicopee, Mass. for a 90° deflection cathode ray tube. However, as this was available and required no additional redesign, it was used for this 70° receiver.

The horizontal yoke is parallel connected and has an inductance of 45 μh.

The vertical winding, when series connected, has a total inductance of 40 mh. In the application in this receiver the vertical windings were parallel connected to reduce the series resistance in the circuit. Therefore, the vertical yoke specifications as used in the receiver described herein would be about 9 mh inductance and approximately 11 ohms resistance.

Sickles number for this yoke is 17496-11.

Conclusions

From the observations and information gained in the designing and building of this TV receiver it may be concluded that large screen, completely portable battery operated, transistorized television receivers are feasible. It can further be concluded that such receivers may be designed and built with currently available transistors to have performance and reliability comparable with that of many commercial tube receivers.

The receiver presented herein has not been completely evaluated for performance over wide temperature ranges or under varying signal conditions. It has, however, been field tested in strong signal areas such as New York City, and in semi-fringe areas 30-50 miles from the transmitter. In each case the receiver worked well with a simple rabbit ear type indoor antenna.

The results of the field tests, the hundreds of hours of operation of the receiver during setup and measurements and the reliability while being transported have indicated that there is no tendency for transistor failures or erratic performance. It is, therefore, concluded that the receiver described herein may be redesigned into a practical production item which may be sold at a cost which does not greatly exceed that of current TV receivers.

Acknowledgements

The author wishes to acknowledge the assistance of D. R. Baker, T. C. Lawson, and J. Specialny, Jr. in the design and construction of this receiver and also the many valuable comments and suggestions of C. D. Simmons.

Design Considerations For Wide Bands Transistorized VHF Amplifiers

S. E. LIPSKY* J. F. SIEGEL*

This article describes the basic design consideration for transistorized wide-band power matched amplifiers as used for *if* work. The power match equations are derived and a comparison is made between the transistor's figure of merit and that of the vacuum tube. A 100 megacycle *if* amplifiers described and a schematic diagram is presented to indicate utilization of the design information.

THE DESIGN of transistor *if* amplifiers differs significantly from tube design practice in that it is possible to obtain high gain at wide bandwidths with synchronous tuning, as compared to the more common staggered, or multiple adjustment networks found in vacuum tube amplifiers.

This paper will develop the design criteria for the general transformer coupled power-matched amplifier and describe a 100 megacycle transistorized *if* amplifier with a voltage gain of 70 db at an overall bandwidth of 20 megacycles.

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Derivation Of Equations

Figure 1 is an equivalent four terminal circuit representation of a single stage transistor amplifier fed from a current generator of internal impedance R_G. C_i and C_o are the total input and output capacities, R_{in} and R_o are the real parts of the transistor input and output impedances, R_p is the coupling network loss resistance, and R_L is the output load. The circuit representation shown here is valid at all frequencies at which the coupling and by-pass capacities may be neglected, with the further qualification that R_L, R_o, C_i, and C_o all vary with frequency. The output circuit is fed by a current generator of magnitude βi_{in} and is tuned by C_o. Transformer coupling may be used to couple iterative stages of impedance ratios of approximately 10 to 1. The secondary of the network shown is untuned and tightly coupled to the primary which is slug tuned. The voltage gain of the amplifier at resonance may now be computed:

$$V_{out} = \beta i_{in} \frac{R_o R_p R_L}{R_o R_p + R_o R_L + R_p R_L}$$

where β is the common emitter current gain. For the wide bandwidth case under consideration R_p may be neglected, so that

$$V_{out} = \beta i_{in} \left(\frac{R_o R_L}{R_o + R_L} \right)$$

In general: $V_{in} = i_{in} R_{in}$ neglecting input capacitive effects:

$$\text{Voltage gain} = \frac{V_{out}}{V_{in}}$$

$$= \frac{\beta}{R_{in}} \left(\frac{R_o R_L}{R_o + R_L} \right) \qquad (1)$$

The voltage gain at the secondary of the transformer of turns ratio n:1, working into a load R'_L:

$$\text{where } R_L = n^2 R'_L$$

$$(VG)_{sec} = \frac{\beta}{nR_{in}} \left(\frac{n^2 R_o R'_L}{R_o + n^2 R'_L} \right) \qquad (2)$$

For maximum voltage gain at the secondary for a fixed load, differentiate with respect to n and set equal to zero. Thus,

$$\frac{\partial}{\partial n} (VG)_{sec} = \frac{\beta R_o R'_L}{R_{in}} \frac{\partial}{\partial n} \frac{n}{R_o + n^2 R'_L}$$

$$= \frac{\beta R_o R'_L}{R_{in}} \left[\frac{(R_o + n^2 R'_L) - 2n^2 R'_L}{(R_o + n^2 R'_L)^2} \right] = 0$$

$$R_o + n^2 R'_L = 2n^2 R'_L$$

$$n = \sqrt{\frac{R_o}{R_L}}$$

$$\text{or: } R_o = n^2 R'_L$$

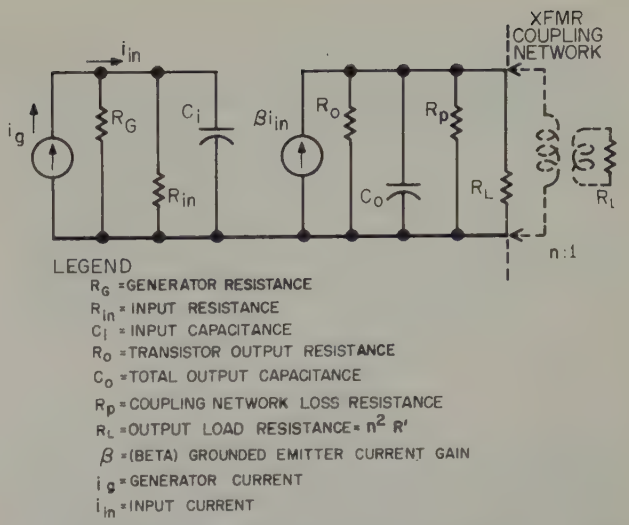

Fig. 1—Equivalent four terminal circuit representation of a single stage transistor amplifier.

But this is the condition of maximum power transfer. Therefore we conclude that maximum voltage gain will be obtained at maximum power transfer or when substituting in equation (2):

$$max\ (VG)_{sec} = \frac{\beta}{2R_{in}} \sqrt{R_o R'_L}$$

but for an iterative stage $R'_L = R_{in}$ where R_{in} is the input impedance of the next stage and the voltage gain becomes:

$$max\ (VG) = \frac{\beta}{2} \sqrt{\frac{R_o}{R_{in}}} \qquad (3)$$

The bandwidth of the circuit is: [1]

$$BW = \frac{1}{2\pi RC} \qquad (4)$$

$$\text{Where: } R = \frac{R_o}{2} = \text{total circuit } R$$

$$C = C_o + \frac{C_i}{n^2} + C\text{stray}$$

$$BW = \frac{1}{\pi R_o C}$$

The gain bandwidth product at maximum voltage gain:

$$(G)\ (BW) = \frac{\beta}{2\pi C \sqrt{R_{in} R_o}} \qquad (5)$$

From the preceeding discussion certain points have been established: maximum gain will be obtained under power matched conditions, the bandwidth is dependent upon the circuit capacity and high values of gain are obtainable with low values of β as a consequence of the ratio of R_o/R_{in}.

Transistor Amplifier Vs. Vacuum Tube Amplifier

An interesting comparison may be drawn between a transistor amplifier and a vacuum tube amplifier if the figures of merit are obtained. For the transistor amplifier working into a resistive load:
From (1) and (4)

$$\text{Voltage gain} \times BW = \frac{\beta}{R_{in}} \left(\frac{R_o R_L}{R_o + R_L} \right) \times \frac{R_o + R_L}{2\pi C (R_o R_L)}$$

$$= \frac{\beta}{2\pi C R_{in}} \qquad (6)$$

But β/R_{in} is equivalent to g_m for a vacuum tube since:

$$\frac{\partial i_{out}}{\partial e_{in}} \frac{\partial i_{in}}{\partial i_{in}} = \frac{\beta}{R_{in}} \qquad (7)$$

Reducing equation (6) to:

$$\text{gain} \times BW = \frac{g_m}{2\pi C} \qquad (8)$$

This indicates that the gain bandwidth product of a transistor amplifier is the same as for a vacuum tube amplifier[2] for the condition of resistive loading. In the usual case, however, a transistor amplifier feeds another identical stage through an impedance transforming device.

From equation (6) at the secondary of the coupling network the gain bandwidth product is:

$$(\text{gain} \times \text{bandwidth}) = \frac{1}{n} \times \frac{\beta}{2\pi R_{in} C} = \frac{g_m}{2\pi n C} \qquad (9)$$

Equation (9) shows that the gain bandwidth product for an iterative stage is no longer a constant, but is a function of the turns ratio of the coupling transformer. It is, therefore, not possible to exchange gain for bandwidth directly as in a vacuum tube amplifier.

The results of the above analysis may become more apparent upon examination of *Fig. 2*, a plot of available gain versus bandwidth for a typical *vhf* diffused base mesa transistor as compared to a typical high frequency pentode (10,000 micromhos transconductance). For bandwidths greater than about 15 megacycles the iterative transistor amplifier is capable of higher voltage gain than the tube amplifier. For narrower bandwidths the tube amplifier has higher gain capabilities since the resistive loading used to obtain large bandwidths for the vacuum tube amplifier may be removed leaving the relatively high plate resistance as the tuned circuit lead. For narrow bandwidths the transistor amplifier requires an increase in the shunt capacity (equation 4) which may make the construction of physically realizable coils difficult at low *if* frequencies.

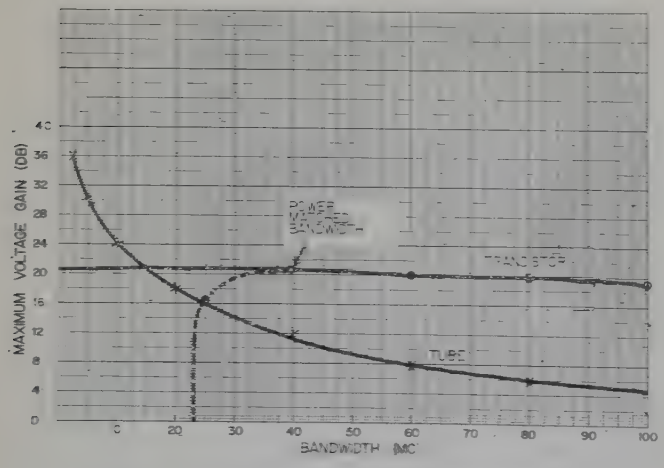

Fig. 2—Available Gain *vs.* Bandwidth.

The matched power bandwidth of the transistor amplifier is approximately 40 megacycles. Above this frequency gain is exchanged for bandwidth; below this frequency circuit capacitance must be added to achieve narrow bandwidths for the same gain. The dotted line indicates the voltage gain of the transistor amplifier if this loading is omitted.

The output impedance of a vacuum tube pentode may typically be about 250,000 ohms at *if* frequencies. Tuned circuit impedances, however, are in the order of 50,000 ohms at *if* frequencies, thereby imposing an upper limit to tube amplifier gain capabilities in narrow band *if* systems.

For wide band tube amplifiers additional loading in the form of a fixed resistor, R_D, must be added across the tuned circuit to achieve the bandwidth. Since the value of this resistor is considerably lower than the tube output impedance in parallel with the turned circuit impedance, the resistor becomes the gain and bandwidth determining factor. The familiar vacuum tube equations reduce to:

$$Gain = g_m R_D$$

$$BW = \frac{1}{2\pi R_D C}$$

This indicates that by varying R_D, gain may be exchanged for bandwidth. Power gain and transformer coupling are not usually considered in the class A grounded cathode amplifier since the grid circuit of the next stage does not consume power.

Gain Bandwidth Capabilities

The gain bandwidth product at maximum voltage gain for the transistor amplifier has been derived as equation (5), while that of the vacuum tube amplifier is stated in equation (8). An interesting comparison may be made between a 2N509 transistor and a 7077 *uhf* triode vacuum tube. For the 2N509 transistor:

$$\beta \text{ at } 100\ mc = 15\ db = 5.6$$

$$R_{in} = 50 \text{ ohms}$$

$$R_o = 500 \text{ ohms}$$

$$C_o = 1.5 \times 10^{-12} f$$

$$(G)\ (BW) = \frac{5.6}{(2)\ (\pi)\ (1.5)\ 10^{-12}} \frac{1}{\sqrt{(50)\ (500)}}$$

$$(G)\ (BW) = 3760\ mc$$

This compares with a figure of 1150 for the 7077 triode. The equivalent transconductance of the 2N509 may also be computed from equation (7):

$$g_m = \frac{\beta}{R_{in}} = \frac{5.6}{50}$$

$$g_m = 112{,}000\ \mu mho$$

This value may be compared to the value of 10,000 micromho for the 7077 tube.

From the foregoing discussion it is apparent that the transistor is capable of vastly improved performance over a corresponding tube design at the wide bandwidths under consideration. An additional advantage may be realized in that the transistor amplifier is synchronously tuned since the bandwidth of the transformer coupling network is determined primarily by the single tuned primary circuit. The usual operating power, form factor and reliability advantages of transistorization are further enhanced by the elimination of heater leads and the problematical choke decoupling.

A 100 Megacycle IF Amplifier

Figures 3, 4, and 5 are photographs and a schematic diagram of a 100 megacycle *if* amplifier developed in accordance with the design principles outlined above.

The circuit consists of five synchronously tuned amplifier stages. Four of the stages are iterative and power matched. The fifth stage works into a diode detector followed by two stages of *d-c* coupled video amplification. The Western Electric type 2N509 (2N1195) type transistor is used throughout.

The overall bandwidth of the *if* amplifier is 20 megacycles at the 3 *db* points and exhibits the characteristics of synchronous tuning (Gaussian shape) as may be seen in *Fig. 6*. The overall system as shown develops 1 volt of video output for a pulsed input of 120 microvolts, at 100 *mc*. The individual stage gains are approximately 15 *db* with the exception of stage 5, which exhibits a voltage gain of 22 *db* since it works into the higher impedance diode load. The overall noise figure of the *if* amplifier is 5 *db*.

A transistor is bi-lateral in nature *i.e.,* there exists both a forward and reverse transfer impedance. Stable operation will occur when an out-of-phase component of the collector current is fed to the base, reducing the capacitive coupling from base to collector—thereby, increasing the reverse attenuation per stage.

Each stage of the amplifier is neutralized by a simple but effective method. A 180 degree phase reversal between output and input voltage is developed in the grounded emitter configuration. The additional 180 degree phase shift, required for neutralization, is

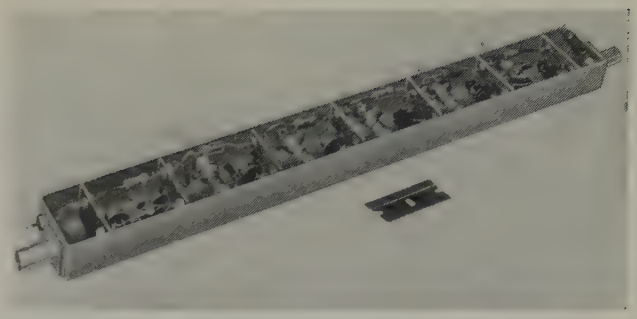

Fig. 3—Photo of the complete 100 *mc.* i-f amplifier.

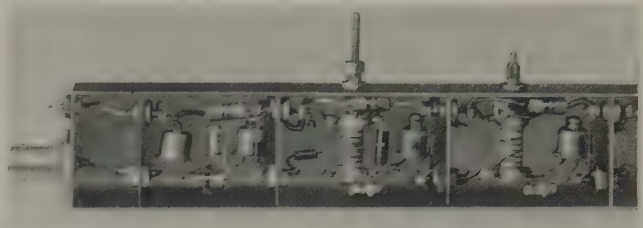

Fig. 4—Close-up photo of amplifier showing details of construction.

achieved by reversing the output leads of the link and feeding the resultant in-phase voltage back to the base. An additional gain of 3.2 *db* per stage is obtained in this manner.

The circuit shown is inverted; i.e., the collector is *d-c* grounded and the supply is fed at the emitter. This permits the use of negative ground supply and allows a short physical ground at the primary of the coupling coil. A single battery supply is used for convenience.

The transistors operate with an I_c of 4 milliamperes and at a V_{CB} of 5 volts. The input impedance of a stage is 50 ohms with an output impedance of 500 ohms. The turns ratio of an iterative stage transformer is 3 with the secondary link tightly coupled to the primary.

The stability factor of the circuit shown is 6, which is low enough to insure operation over the desired temperature range of from −55°C to +71°C. There is an increase in gain of 10 *db* at the low temperature limit and a decrease of 10 *db* of gain at the high temperature extreme. This is to be expected since the high frequency beta (h_{fe}) increases with decreasing temperature.[3]

An automatic gain control system in the form of biased shunting diodes across the two input tuned circuits is used to keep the output voltage constant at 1 volt for a wide range of pulse signals. This method of *agc* application was found more desireable than other methods uitlizing bias point changes. The application of *agc* voltage to the base or emitter caused an unacceptable shift in the operating characteristics of the stage so controlled. With the diode method used, there is no appreciable change in bandwidth or shift of center frequency over the specified temperature range.

Examination of the photographs, *Fig.* 3 and 4 shows

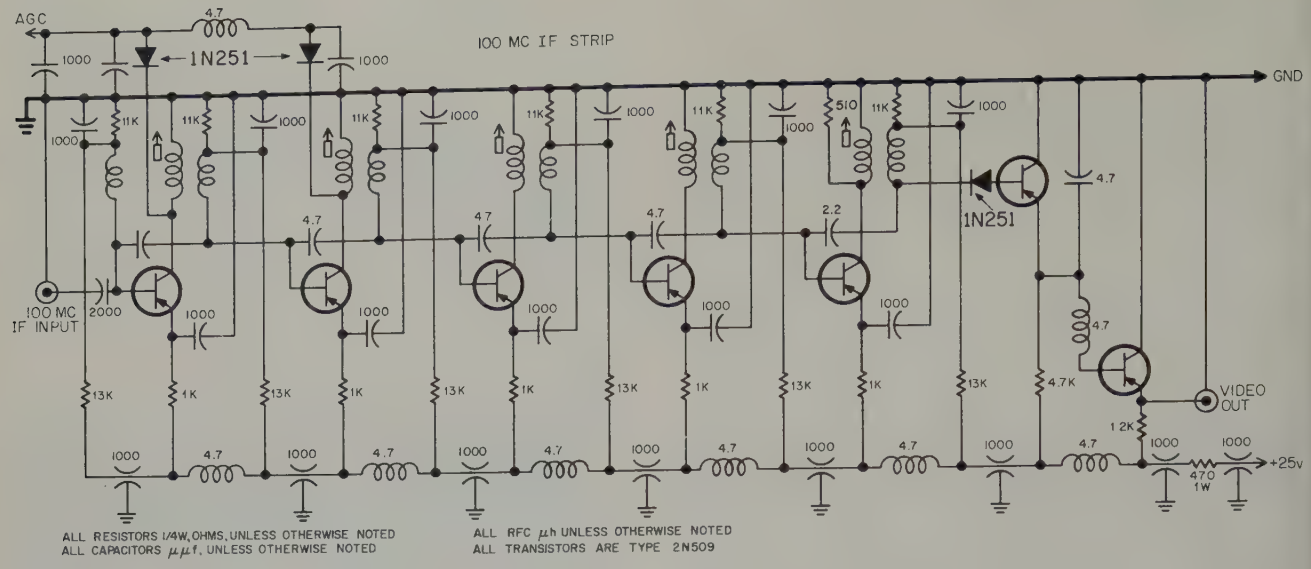

Fig. 5—Schematic of the 100 *mc* i-f amplifier.

the simplicity of construction and layout possible with a transistor *if* amplifier strip. The coils are wound on 1/4 inch ceramic coil forms and are tuned with powdered iron slugs. The secondary links are wound directly over the primary for maximum mutual inductance.

Design Considerations and Conclusions

The design techniques described herein are applicable to wide band *if* amplifiers up to the *uhf* limit of the current gain since some usable voltage may be obtained as a function of the ratio of output to inpedances. A practical limit, however, will be the noise figure which tends to increase rapidly above 160 megacycles. Gains of several *db* have been obtained at frequencies as high as 400 megacycles subject to this limitation.

Conclusions

The design considerations for wide band transistor *if* amplifiers have been defined and described and comparisons of the capabilities of the *vhf* transistor to the vacuum tube have been drawn to illustrate some obvious advantages of transistorization. Careful design and adequate precautions will permit the design of extremely compact *rf* packages permitting complete transistorization of *vhf* equipment.

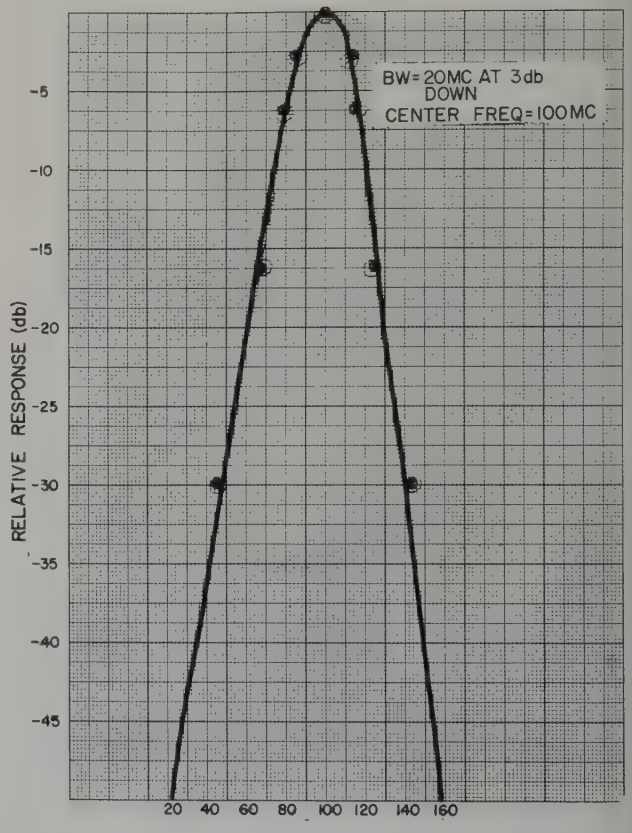

Fig. 6—Bandwidth characteristic of the amplifier.

References

[1] Valley and Wallman, *"Vacuum Tube Amplifiers"* p. 169
[2] *Op cit.*, p. 172
[3] Western Electric Technical Data Sheet, Type 2N509, Issue 2, p. 7, *Fig. 18.*

Maximum Power Dissipation In Transistors

HARRY E. SCHAUWECKER*

This article discusses the various limitations on maximum power dissipation in transistors. In particular such topics as thermal resistance and its influence on junction temperature at maximum collector dissipation are discussed. Collector load lines and maximum power hyperbolas and their usage is explained. Thermal runaway considerations are developed and the inter-relationships of stability factor, collector supply voltage, thermal resistance, ambient temperature, and power dissipation are presented. The examples are given for calculating the maximum allowable power dissipation for limitations based on thermal resistance as well as thermal runaway.

IN GENERAL, THE MAXIMUM POWER dissipation of a transistor is governed by thermal considerations which involve the maximum operating temperature of the transistor junction. In the case of germanium, the maximum junction temperature lies in the range 85° to 100°C. Silicon, on the other hand, because of its higher temperature properties, may be operated to substantially higher temperatures. Typically, the maximum junction temperature of a silicon transistor will lie in the range 150° to 200°C with some manufacturers claiming maximum junction temperatures of 150°, some 170°C, and some range as high as 200°C.

The basic considerations that govern the operation of a transistor then are:

1. The maximum ambient temperature to which the transistor will be subjected.
2. The temperature rise in the transistor, which is largely due to the power dissipation.

Equation 1 illustrates the maximum power which may be dissipated by the transistor at any given ambient temperature.

$$P_{C\,max} = (T_J - T_A)/\theta_T \qquad (1)$$

where T_J is the maximum junction operating temperature, T_A is the maximum ambient temperature, θ_T is the thermal resistance of the transistor to the ambient source and P_C is the maximum collector dissipation. In general, the manufacturer will specify the maximum operating junction temperature. The thermal resistance θ_T, will be composed of the thermal resistance from transistor junction to the shell or case of the transistor plus the thermal resistance from the shell or case of the transistor to the external ambient temperature. The total thermal resistance gives a measure of the temperature rise which will occur at the transistor junction as a result of a given power dissipation. It is generally measured in terms of degrees C per watt.

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A transistor mounted in free air will have a thermal resistance from junction to case. The heat generated at the junction then must be carried away by means of radiation and convection. The thermal resistance from transistor junction to case may be reduced by connecting the collector junction to the case or by filling the transistor housing with some heat conducting, electrical insulating material such as silicone grease or aluminum oxide powder. Since heat is carried away only by the processes of convection and radiation, the thermal resistance is rather high. In order to reduce the external thermal resistance, the transistor may be mounted in a transistor clip which will help to carry heat away by conduction or the transistor may be fastened to a heat sink. The heat will then be carried away by conduction in addition to convection and radiation. Equation 1 indicates that in order to achieve high collector power dissipation, a low thermal resistance must be obtained. The high power transistors make use of the technique of mounting the collector junction directly on the case of the power transistor achieving a thermal resistance as low as 0.3°C per watt but typically averaging 1 to 1.2°C per watt. This is the thermal resistance from transistor junction to the transistor mounting base. The transistor may then be mounted on a metal plate which serves as a heat sink. The heat sink will contribute an additional thermal resistance which is dependent upon the mass and area of the heat sink.[1,2] A low thermal resistance may be obtained by choosing a heat sink with a large physical area so that a large amount of heat may be radiated, and convection is maximized. The two thermal resistances then may be characterized as the temperature rise per watt which occurs from transistor mounting base to transistor junction by virtue of the internal thermal resistance of the transistor and the temperature rise which occurs from outside ambient to transistor mounting base as a result of the thermal resistance of the heat sink. Both of these thermal resistances should be minimized in order to achieve maximum

power dissipation. *Fig. 1* shows a typical set of curves which gives the maximum power dissipation for any transistor as a function of the thermal resistance and maximum transistor mounting base temperature (which may be the maximum ambient temperature if the thermal resistance includes the thermal resistance of the mounting base).

Effect of Maximum Power Dissipation on Circuit Consideration

The maximum power considerations involved in small signal or linear power amplifier design involving transistors are similar to those that occur in vacuum tube circuit design. In *Fig. 2*, a typical family of collector characteristics is shown. Since the collector characteristics are plots of collector voltage versus collector current, a locus of constant power dissipation appears as a hyperbola on this graph. A typical power locus is indicated. If a load line is drawn on this graph as shown, it may be seen that the maximum power dissipated occurs on the line at the point where the highest power hyperbola is just tangent to the load line. Thus in a Class A power amplifier, the maximum power is actually dissipated under quiescent conditions. The procedure for determining circuit configurations in a power amplifier using transistors then is to locate the maximum power hyperbola by using the value of collector power calculated from the above set of conditions. The maximum voltage and/or maximum current points are then located on the abscissa and ordinate respectively. In general, the maximum voltage will be the governing limitation. A load line may then be drawn through the maximum voltage point and just tangent to the maximum power hyperbola. This is the load line of maximum power dissipation.

When a transistor is used as a switch, it generally has two stable states; one when the transistor is in saturation and the other when the transistor is cut off. When the transistor is in saturation, the voltage is typically a fraction of a volt while the current is at its maximum value. Since the voltage is small, the power dissipated when the transistor is in saturation is extremely small. When the transistor is in the cutoff state, the full applied voltage occurs across the transistor but if the transistor is truly reverse biased, the collector current (the leakage current) is extremely small and thus the power dissipated in the cutoff condition is very low. Thus it is possible for a transistor to switch a power much greater than its own maximum collector dissipation when used as a switch. In this application, a load line will apply but since the transition from cutoff to saturation or vice versa generally occurs very rapidly, the transistor is only at the maximum power dissipation point for a very short period of time. In this mode of operation, a collector power dissipation much greater than the average power dissipation may be used. The design considerations involve the interrelationship of maximum power dissipated, speed of switching and the thermal time constant of the transistor junction. The total power generated in the junction is integrated over the period of transition from one state to the other state. It is possible to average this power over the transition period and make use of the thermal

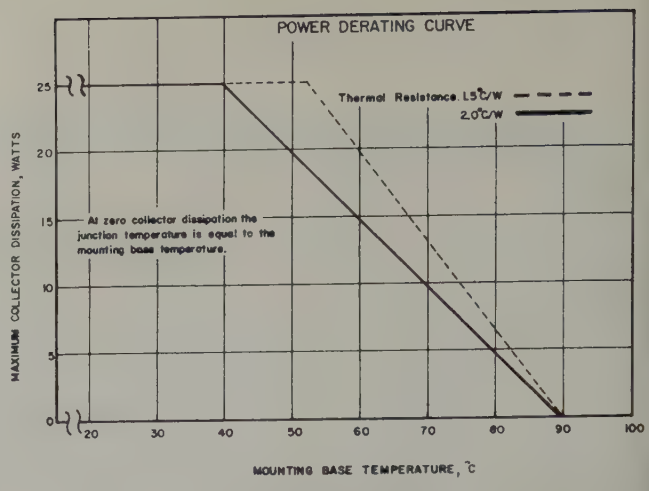
POWER DERATING CURVE
Thermal Resistance 1.5°C/W
2.0°C/W
At zero collector dissipation the junction temperature is equal to the mounting base temperature.
MAXIMUM COLLECTOR DISSIPATION, WATTS
MOUNTING BASE TEMPERATURE, °C

Fig. 1—Maximum Collector Dissipation *vs.* Thermal Resistance and Mounting Base Temperature.

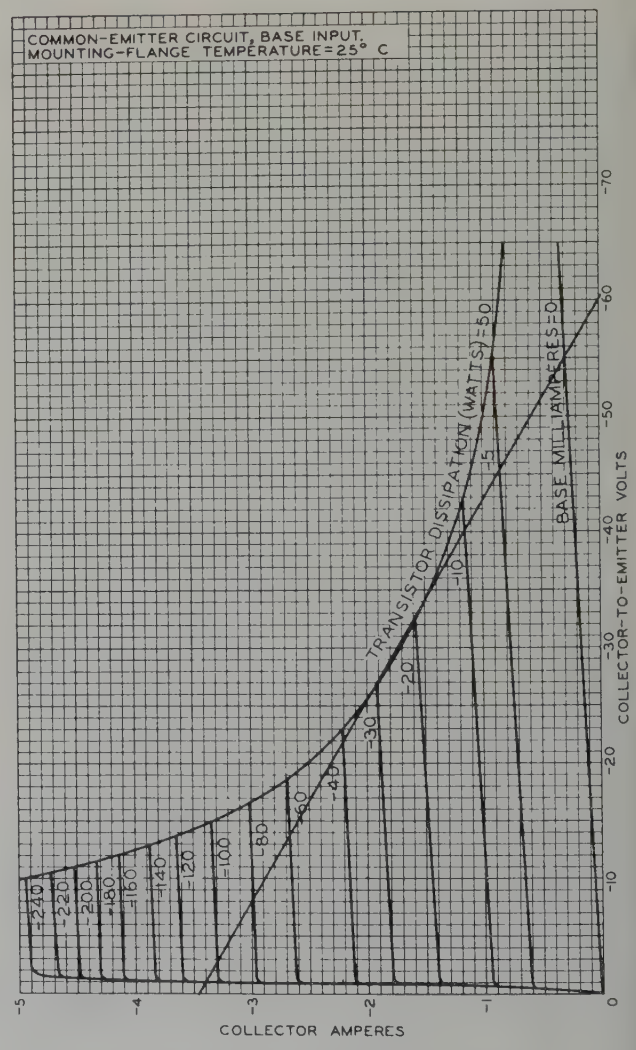

Fig. 2—Typical collector characteristics.

time constant of the junction to determine the actual temperature rise of the junction during transition. Using this technique, it is frequently possible to dissipate, for a short period of time, a collector power that is many times greater than the average collector power which can be dissipated. Some manufacturers give curves showing the duty cycle of such switching configurations and the peak power which may be dissipated under these conditions. Power dissipations 10 to 15 times greater than the average collector power dissipation are thus allowable.

Illustrative Computation

A germanium power transistor with a thermal resistance from junction to mounting base of 1.2°C watt and a maximum junction temperature of 95°C is to be used as a power amplifier in a maximum ambient of 55°C. If the transistor is mounted on a vertical aluminum plate with heat dissipation by means of radiation and convection, the thermal resistance will be approximately 3.8°C/W. The exact thermal resistance of an aluminum plate is a function of the area of the plate, the thickness and whether the plate is mounted vertically or horizontally. The total thermal resistance from transistor junction to ambient is $3.8 + 1.2 = 5°C/W$. The maximum allowable power dissipation is therefore:

$$P_C = \frac{T_J - T_A}{\theta_T} = \frac{95°C - 55°C}{5°C/W} = \frac{40°C}{5°C/W} = 8.0W$$

Thermal Runaway Considerations

Since the transistor is essentially composed of two junction diodes and since a junction diode has a characteristic leakage current which flows in the diode even when it is back biased, the transistor likewise has a leakage current which flows when the diode is back biased. The leakage current referred to varies with temperature in an exponential manner. Thus a 10°C increase in temperature will produce approximately a twofold increase in leakage current. The change in collector current produced as a result of changes in I_{C0} may be given by

$$\Delta I_C = S_C \Delta I_{C0} \qquad (2)$$

Where S_C is defined as the collector circuit stability factor and is a function of the bias network used. S_C will take on values ranging from 1 to $1/(1-\alpha)$ for the common emitter stage depending on the bias network stability. The increase in I_{C0} produces an increase in collector current which in turn produces an increase in collector power dissipation. The increase in collector power dissipation causes a corresponding increase in junction temperature which in turn creates a further increase in the leakage current I_{C0}. If the factors relating these various parameters vary in a certain manner, it is possible to achieve a runaway condition where the thermal leakage current increase will produce a junction temperature increase which is greater than that which can be carried away by the heat sink. This thermal runaway consideration can be illustrated algebraically by Equation 3.

$$\frac{\Delta I_C}{\Delta I_{C0}} \cdot \frac{\Delta I_{C0}}{\Delta T} \cdot \frac{\Delta T}{\Delta P_C} \cdot \frac{\Delta P_C}{\Delta I_C} < 1 \qquad (3)$$

In this equation we may define the various derivatives as shown below:

$\frac{\Delta I_C}{\Delta I_{C0}} = S_C$, the collector stability factor

$\frac{\Delta I_{C0}}{\Delta T} = K_1 I_{C0} = K_2 T_a$, the factor which indicates the increase in I_{C0} for an increase in temperature

$\frac{\Delta T}{\Delta P_C} = \theta_T$, the thermal resistance of transistor and heat sink

$\frac{\Delta P_C}{\Delta I_C} = V_C$, the quiescent collector to emitter voltage

From the above it is clear that there is an interrelationship between the stability factor, S_C, the ambient temperature, T_A, the thermal resistance, θ_T, the collector power dissipation, P_C, and the collector supply voltage V_{CC}. Since the I_{C0} is a function of junction temperature which in turn is dependent upon the ambient temperature and the temperature rise produced by the collector dissipation, we find that for a given transistor we may plot a family of curves which indicate the maximum power which can be dissipated in the transistor for a given stability factor and collector supply voltage. *Fig. 3* shows such a family of curves. It will be noted that as the ambient temperature increases, less power can be dissipated in the transistor if thermal runaway is to be prevented. Likewise, there is a stability factor-supply voltage product which may not be exceeded for any given ambient temperature and collector dissipation. It is possible to compromise either the stability factor or the supply voltage in order to satisfy these conditions.

For the most part a graph as shown above is not furnished by the manufacturer although there are a few instances in which this information is provided. Proper circuit design requires that the engineer take into consideration the circuit stability factor, the ambient temperature, the thermal resistance and the collector supply voltage in arriving at an allowable collector dissipation. This restriction on the maximum collector dissipation is in addition to the absolute maximum power dissipation considerations referred to previously.

Illustrative Computation

An audio amplifier stage is to be designed with a

circuit stability factor of 10. The supply voltage available is 12 volts and the maximum ambient temperature is 50°C. What is the maximum allowable collector dissipation assuming a collector power dissipation of 150 *mw* at 25°C and a 2.50 *mw*/°C derating factor to 85°C?

On the basis of thermal resistance the maximum junction temperature is found by derating the transistor from 25°C to 50°C at 2.5 *mw*/°C. Thus the maximum power dissipation is

$$P_{C\ max} = 150 - 2.5\ mw/°C\ (25°C) = 87.5\ mw \quad (4)$$

However referring to *Fig. 3* we note that for a stability factor of 10 and a collector supply voltage of 12 volts we obtain a stability factor-collector-to-emitter voltage product of 120. This product at an ambient temperature of 50°C gives a maximum allowable collector dissipation of 20 *mw*. Since this figure for maximum power dissipation is lower than the previous figure, thermal runaway is the limiting factor. If on the other hand we had designed for a stability factor of 3, we would have obtained a maximum allowable power dissipation of 50 *mw* for the transistor.

While all the above remarks apply to silicon transistors equally as well as to germanium transistors, it is well to recall that the maximum junction temperature of a silicon transistor is considerably higher than that of a germanium transistor and furthermore, since the leakage current, I_{C0}, in a silicon transistor is several orders of magnitude smaller than the equivalent leakage current in a germanium transistor, the thermal runaway conditions described in the section immediately above may not be as stringent for the silicon transistor as for the germanium transistor.

Minor increases in the junction temperature of a transistor will shorten the life of the device while not necessarily destroying it. The shortened life is due to both a change in the characteristics of the transistor as well as increased surface contamination due to outgassing within the device. A substantial increase in the operating junction temperature will result in breakdown in the transistor resulting in a short between collector and emitter.

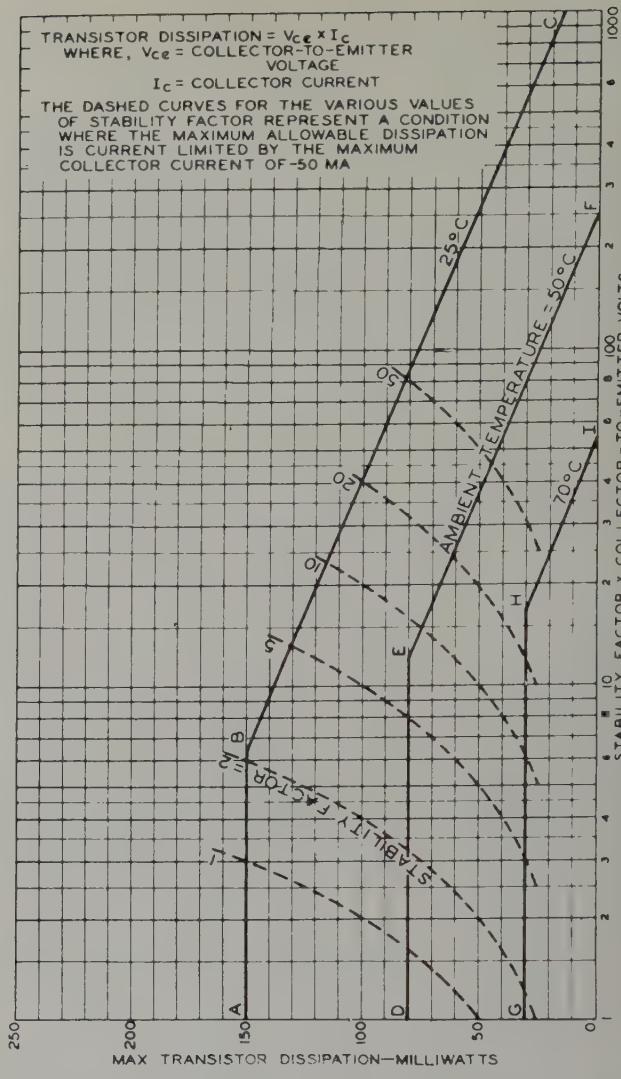

Fig. 3—Maximum Power *vs.* Stability Factor x Collector Voltage

References

[1] J. R. Baum, "Thermal Considerations In The Use Of Power Transistors," *Electronic Design*, June 19, 1959.

[2] "Applying Power Transistors To Control," *Control Engineering*, October 1956.

APPLICATIONS ENGINEERING DIGEST NO. 24

VHF Transistor Power Stages; Texas Instruments Inc., Dallas, Texas.

Transistorized vhf power oscillators and amplifiers can be designed without difficulty to provide reasonable assurance of optimum performance. The essential requirements are proper load impedance, coils and capacitors having sufficiently high Q, a proper feedback path for the oscillator, and a physical layout compatible with the frequency.

The oscillators and amplifiers to be described are power stages. A large voltage swing at the collector is assumed.

Common-base operation is preferred for the following reasons. The transistor

can generally be operated at a higher d-c collector voltage because the common-base breakdown voltage is higher. Experimental results show that both output and efficiency are somewhat higher than in a common-emitter stage. The gain of a common-base amplifier may be lower, but this is usually not significant in a power stage. In some instances, the common-base stage may have more gain. Fnally, the feedback path for an oscillator is more easily estabished in a common-base connection.

Design Analysis

The load impedance, R_L, at the collector is dictated by the output power and the collector voltage. Its maximum value is given by:

$$R_L = \frac{E_{bb}^2}{2 P_o} \quad \ldots\ldots\ldots \quad (1)$$

where E_{bb} is the battery voltage and P_o is the output power. This assumes that peak a-c voltage is equal to the battery voltage. It is often impossible to swing the collector voltage this much, particularly at higher frequencies. In this case, R_L will be less (often considerably less) than the value given above.

Since predicting large-signal behavior of a transistor at vhf is difficult, a load-matching network is required to obtain the desired performance. The network shown in *Fig. 24.1* is frequently used for impedance matching. The range of load impedance may be determined with relative ease and a wide variety of load conditions may be accommodated.

The maximum value for R_L is determined by Eq. (1). R_o, the output load resistance, is known (usually 50 ohms). The loaded Q of the entire circuit is subject to certain limitations. Since a low value of loaded Q permits excessive transmission of harmonic frequencies, it should not be less than 5, and preferably not less than 7. Maximum Q is limited by the realizable Q of the circuit elements; therefore, C1 must be a high-Q capacitor. The Q of L1 is usually the limiting factor and the loaded circuit Q should not exceed 10 percent of the inductor Q so that not more than about 10 percent of the available power will be lost in L1. If inductor size is not too small, Q's of 200 to 300 are possible.

Input Matching Section

While a π network is possible, the Q is very low for a low-impedance source. Therefore a resonant matching system is best. A simple and effective scheme is shown in *Fig. 24.2*.

At high frequencies, the input resistance of the transistor is approximately equal to r_b'. C2 is selected for the minimum Q desired:

$$X_{C2} \cong 2Q_{(min)} r_b'$$

The factor 2 is included to account for the loading of the source at impedance match. L1 and C1 are selected to resonate with C2 at the operating frequency. C3 will serve as an impedance matching capacitor. Typical values for X_{C3} might range from 1/3 to 3 times r_b'. The input tap on L1 should be located experimentally to provide the maximum available power at the transistor input.

Oscillator Design

Adding a feedback circuit to the collector matching section will complete the oscillator design.

The common-base circuit is well suited for oscillation since the emitter current is nearly in phase with the collector current. Direct collector-emitter feedback through the internal transistor capacitance (at high frequencies) or with an externally connected collector-emitter capacitor (at low frequencies) will always produce oscillation.

Oscillation occurs at that point on the resonant-circuit impedance curve where the phase of the feedback is correct. An adjustment of the magnitude of the feedback voltage is needed. This may be a small variable capacitor from emitter to ground (at high frequencies) or from collector to emitter (at low frequencies).

The circuit of a typical 200-mc oscillator is shown in *Fig. 24.3*. The 2N1141 will give 60 to 100 mw in this circuit with 20 volts from collector to base and 10-ma emitter current.

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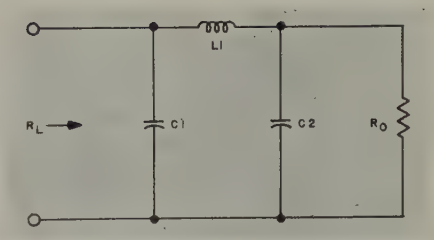

Fig. 24.1—Load matching pi network.

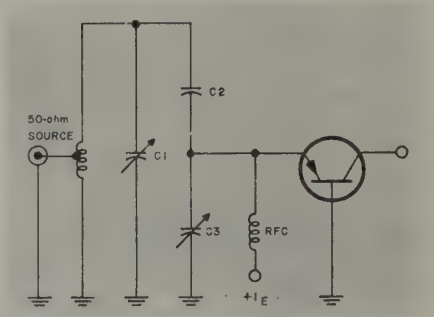

Fig. 24.2—Resonant input system for VHF amplifier.

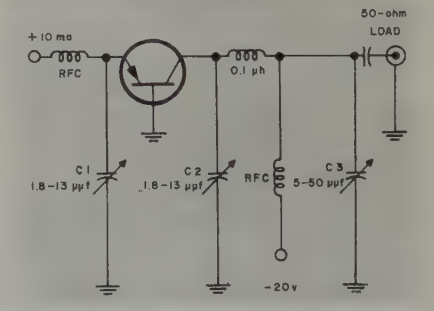

Fig. 24.3—200 *mc* oscillator.

APPLICATIONS ENGINEERING DIGEST NO. 25

Improved Magnetic Core Digital Circuitry; National Bureau of Standards, Washington 25, D.C.

Continuing research on electronic computer circuitry and components at the National Bureau of Standards for the United States Air Force Cambridge Research Center has resulted in an improved digital magnetic amplifier. By modifying a magnetic core amplifier circuit developed earlier at the Bureau[1], E. W. Hogue has designed a new circuit with improved stability, increased logical gain, and a faster complementer.

Semiconductor diode gating, because of its economy, flexibility, and dependability, is widely used to perform the logical functions of a high-speed electronic computer. To overcome the loss of signal power through the gates, amplifiers are inserted into the gating structure at intervals to regenerate the signal. Although vacuum tubes and transistors are commonly used to amplify the signal, saturable core reactors also show promise. The Bureau has therefore been investigating the use of these components as amplifiers because of their compactness, dependability, and low power consumption.

Essentially, these amplifiers consist of diode-resistor networks associated with miniature saturable-core reactors driven by a "clock." The "clock" in this case is a 300 kc low-impedance sinewave source. An amplifier serves to transmit pulses, corresponding to binary "ones", or no pulses—zeros—depending on the input to the stage.

Fig. 25.1 is the circuit diagram of a

magnetic core amplifier with associated circuitry. Between the vertical dotted lines are two stages; the upper stage is an amplifier, and the lower one is a complementer. Outside of the dotted lines are diode-resistor networks to provide the logical AND-OR gating. The stages can receive an input signal from the OR-gate.

Most of the power gain of the amplifier is provided by the saturable core reactor. Current from clock e_c', together with the total current from R_0 and all the resistors of the driven AND-gates in parallel, serve to return the reactor to the state of negative saturation during each half-cycle of e_c'. During the positive half-cycle, e_c' has no effect on the reactor because diode D_0 is back-biased. The reactor, left to itself, remains negatively saturated once put in this state and presents such a low impedance to the driven AND-gates that they remain held at ground level during the negative half-cycle. Thus, binary zeros are transmitted.

If the AND-gates at the left of the diagram are not held at ground level during the negative half-cycle of e_c (which is opposite in phase to e_c'), a negative signal reaches the input winding of the reactor. Since this winding is in the opposite sense to that of the output, the negative signal saturates the positive half-cycle of e_c'. Finally, during the ensuing negative half-cycle of e_c', the driven AND-gates return the reactor from positive to negative saturation. The reactor then presents a high impedance to the gates, so that they are not held at ground. The gates therefore transmit binary ones.

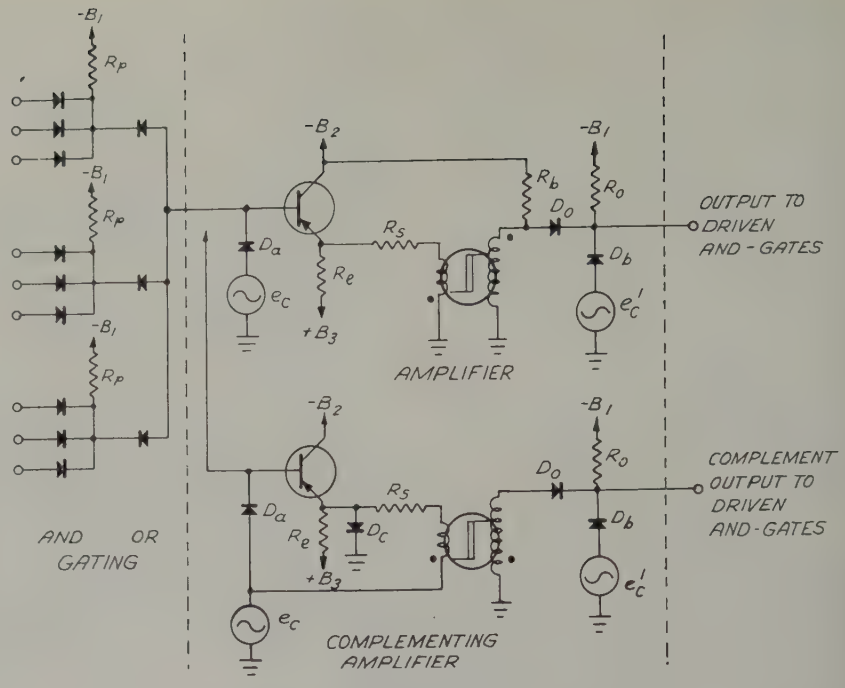

Fig. 25.1—Transistorized magnetic core circuitry.

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APPLICATIONS ENGINEERING DIGEST NO. 26

Transistor Chopper Applications; Solid State Electronics Co., Van Nuys, Calif.

The solid state chopper utilizes a matched pair of transistors which are alternately switched on and off. Although a single transistor can be used to accomplish the same function, the use of a matched pair connected in the proper manner has the advantage of a lower signal null in the order of tenths of a millivolt or less and also provides a much greater degree of drift stability over a wide temperature range.

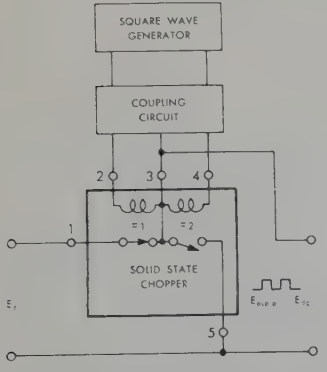

Fig. 26.1—Equivalent switching circuit for solid state chopper.

For simplification and ease of understanding, the equivalent switching circuit is shown in *Fig. 26.1* where the switching action of the matched transistors is represented by two relays. The square wave generator is shown as alternately driving the relays so that when one relay is closed, the other is opened. In this manner, the signal source is alternately connected to the load by relay #1 every half cycle, while relay #2 is open. During the other half cycle, the load is disconnected from the source as relay #1 is opened and the load is shorted by relay #2. As a result, the output across the load will be a square wave having a peak amplitude equal to the input voltage during every half cycle, and zero voltage during the other half of the cycle.

Since the solid state chopper is an inertialess device, extremely high chopping frequencies are obtainable. Frequencies as high as several hundred kilocycles per second have been used for certain applications. Accordingly, the voltage to be modulated may be a time varying function somewhat slower than the chopping frequency.

Drive for the chopper is best supplied by a square wave generator. However, other waveforms, such as a sine wave, may be used for driving the solid state chopper in certain applications where a small amount of ripple is not objectionable. Two typical driving circuits are suggested in *Fig. 26.2.*

The first method *(Fig. 26.2)* is not limited by the frequency response of slightly greater drive voltage. The second method, which utilizes a matched transformer with a center-tapped secondary, has the advantage of isolating the square wave generator should its ground be common with the source or load.

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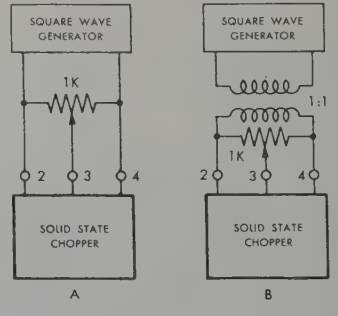

Fig. 26.2—Two suggested coupling circuits for driving the solid state chopper.

Integrated Circuitry, Micro-Miniaturization And Molecular Electronics

WOLFGANG W. GÄRTNER*

This article attempts to answer the question as to what the New Dimension in Electronics means in terms of solid facts. The objectives of micro-miniaturization are outlined; the possible approaches to integrated devices are discussed from the standpoint of technology and circuitry; the reliability problem is considered; various physical effects under exploration at the present time which hold promise for future electronic applications are enumerated; and the implications of the new trend for the electronic industry and the electrical engineer are indicated.

THE ANNOUNCEMENT of a "New Dimension in Electronics" with its press releases and their effect on the stock market, with its encapsulated prototype models and the colorful artistry against a space-age background of satellites and galactic constellations has made the electronic engineer wonder how much solid facts there were behind the many new terms evolved over the last few months. An assessment of the situation therefore appears to be of interest.

What started out in the Micro-Module Program[1] as a joint effort of the U.S. Army Signal Corps and the Radio Corporation of America, has revealed the amazing fact that electronics is still in a major revolution which began with the invention of the transistor but seems to go far beyond the mere replacement of vacuum tubes by transistors. Rather—and this is the essence of the "New Era in Electronics," no matter under what heading it is presented—physics continues to rapidly feed new information to the electronic device designer so that he is able to develop new devices which perform more electronic functions per gram, cubic inch and—hopefully—dollar, than is possible with existing components and circuits.

Radically different as it may seem at first sight the new trend in electronics is actually the natural course of events which began in 1948 when solid state physics and electronics became so intimately and permanently associated through the invention of the transistor.

The potentialities of this trend are great. Orders of magnitude size and weight reductions appear feasible, and the cost of electrical equipment should eventually go down (or more functions will be performed per unit cost). The military, with its need for ever-increasing amounts of electronic equipment, was quick to recognize these potentialities and to add a few specific requirements of its own, thus defining the more immediate goals to be strived for. The emphasis shall be on size reduction and no compromise shall be made on the reliability of the new devices. In addition, the prohibitive cost of maintenance in present circuitry shall be obviated by "throw-away" maintenance, i.e. new systems shall be designed such than an improperly functioning building block shall not be repaired but thrown away. These individual components will therefore not be designed for repairability (maintenance) but rather for high reliability and low cost. As a result of the new approach, circuit and systems design will undergo considerable changes. In the past active and passive components of a certain versatility have been developed and were then assembled into circuits (at relatively high cost and low reliability) to perform certain functions. In the future we shall have on the one hand a given functional requirement, not specified in terms of a circuit but specified by performance only. On the other hand we have the bank of physical effects on which quantitative information rapidly accumulates, especially in the solid state area (but liquids and gases are considered occasionally). The designer will then pick from this bank a combination of physical effects which perform the desired function in the most efficient manner. To build hardware there must be available to him a highly versatile technology which allows him to realize the postulated combination. Circuit design in the present sense will disappear and will be replaced by the design of the "circuit function" component. Furthermore, active and passive components will lose their identity. Presently, most passive components are used to modify the properties of active elements. In the new framework these modifications will be built into the active element making the passive component superfluous. It may also turn out that typical passive functions like filter action may be performed more efficiently with active elements. Thus active and passive components

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[1]See e.g. A. W. Rogers, The Micro-Module Design Concept in Electronics, *Electrical Manufacturing*, July 1958, p. 46, and P. J. Jacobs, Micro-Module Design Progress, *Electrical Manufacturing*, March 1959, p. 78.

will be replaced by active and passive volume elements in the new devices, active elements being those which emit a net flux of energy at the desired frequency, passive elements being those which store or dissipate such energy.

With the general concept thus better defined we may ask ourselves what are the chances of major advances in the forseeable future and what approaches do we take?

We do not want to talk here about repackaging efforts to achieve a uniform geometry of all components and to thus make them amenable to machine assembly. Undoubtedly this approach, which is rapidly being implemented now in the Micro-Module Program, will yield a major size reduction and will reach the large-scale production stage within the next few years. Beyond these immediate objectives it will also provide a suitable standard package and assembly technique for the more advanced devices to be developed, and its form factor may serve as a common denominator for the natural integration of existing and future components. The bulk of the proposed research activity in the New Era in Electronics, however, lies in the next steps, the assembly of circuits on and inside a piece of solid and the realization of an electronic function on a molecular or atomic scale. Major production and use of such novel devices should begin five to ten years from now. Because of our familiarity with the substances and the spectacular successes in the past, semiconductors will play a leading role in these developments in the forseeable future.

Obviously there are various degrees of sophistication to the suggested approaches. The simplest among these deals with the so-called "integrated-circuit building-block." This is a single device in which a whole circuit has been assembled in the most efficient way, eliminating material ordinarily used for the support and protection of the individual components and their interconnections. The active element in most cases is a semiconductor unit operating on the *p-n* junction principle. There are various possibilities for building such devices all of which are being worked on in various industrial and Government laboratories.

One may for example, take an electrically insulating substrate like a suitably prepared ceramic wafer, and deposit on it all the passive components needed in the circuit. This may be done by vacuum evaporation, sputtering, ion beam deposition, electro-plating etc. Then the semiconductor elements which have been pretested and repackaged and possibly re-engineered for small size are added (e.g. soldered) into the passive circuit to complete the device which may then be encapsulated for protection. To insure reliability of the semiconductor elements hermetic sealing will be required until the surface passivation problem has been successfully solved.

In another approach one again takes an inert substrate but deposits the semiconductor element together with the passive components. The obvious important result of this development will be the deposited (vacuum evaporated) transistor base layer. The major obstacle here is the difficulty in depositing thin single crystalline layers of semiconductors, or in depositing a polycrystalline film so thin and pure that recombination at dislocations and grain boundaries does not deteriorate the current amplification.

The above mentioned approaches may both be grouped under the heading of "thin-film" techniques since the entire circuit (except possibly for the semiconductor elements in the first case), will occupy a layer of only a few mils thickness.

A third approach is somewhat different but also highly promising: One uses the semiconductor itself as the supporting substrate and engineers the circuit onto and into it. If one considers that the Siemens-Schuckertwerke Laboratories in Pretzfeld, Germany, pioneers in the high-purity silicon area, have recently produced uncompensated single crystalline silicon of more than 100,000 ohm-cm resistivity at room temperature, this approach appears very feasible. A slab of 2 x 2 x .2 mm, for example, has a resistance of 5 megohms between opposite narrow sides. Lifetimes in this material are very long (milliseconds) and recent advances in the growth of dislocation-free crystals at the General Electric Research Laboratories in Schenectady could make such high-resistivity silicon one of the most ideal substrates available. Although the Army approach at present favors silicon for various sound reasons, germanium may be considered for special uses and III-V compounds may take over when developed to the point where they are competitive in the majority of applications. There is a wealth of techniques at the disposal of the device designer to process such a semiconductor substrate. Liquid and gaseous etching may be used to micro-machine the geometry of the structure using suitable masking. In this area the Diamond Ordnance Fuze Laboratory has done some pioneering work using photo-etch techniques. Vacuum deposition of ohmic and rectifying contacts (injecting if necessary), electroplating of such contacts similar to the surface barrier technique of Philco Corporation, diffusion with suitable masking are all methods available to build one or many transistor and diode-like structures into the basic semiconductor substrate. Passive components such as resistors and capacitors may be deposited on the support layer or machined into it to complete the circuit. The advantage of this method is that it starts out with the single crystalline semiconductor needed for present solid state active devices, so that the success of the approach is not dependent on the breakthrough needed in the field of the deposited single-crystalline semiconductor mentioned earlier.

The question now arises as to what circuits shall be integrated into such a compact device.

The operating points of transistors in many applications are identical or very close so that one could incorporate into the device the three or four bias resistors required in a typical one-battery supply scheme affording a temperature stability typical of military

(or commercial) requirements. Such a measure would eliminate the need to connect three or four resistors to each transistor in a circuit only to achieve the suitable operating point. The above-described self-biasing device needs only one connection to the *d-c* power supply. The biasing arrangement could consist of the conventional temperature-insensitive resistors or it could employ non-linear stabilization using thermistors. In the semiconductors used as substrates for example, a wide variety of resistor temperature characteristics is available depending on impurity content and scattering mechanism. It is thus conceivable that the self biased transistor achieves a stable operating point at lower *d-c* power consumption than its conventional counterpart.

Most amplifier circuits contain coupling capacitors and by-pass capacitors for the bias resistors. If these were built into the transistor structure and were chosen so as to be adequate over the useful frequency range of the transistor, the later addition of such capacitors in a circuit assembly would be superfluous.

It thus appears possible to build a single device which constitutes a complete *RC* coupled iterative amplifier state, not requiring any additional external circuitry. It would have four terminals: one for ground, one for *d-c* bias supply, one for signal input and one for signal output. Any number of them could be connected to form a multiple-stage amplifier. If desired, several such stages may be built into the same device.

From what has been said thus far it is apparent that even a partial integration (e.g. combining only the transistor with its bias network and the necessary by-pass capacitors) will yield a considerable saving in assembly time and size of circuitry. Furthermore, it simplifies circuit design drastically, reducing it to the design of a black-box signal-flow model.

Another interesting application of the integration concept would be unilateralization. It is well known that the internal feedback in transistors has many undesirable effects leading to instability of individual amplifier stages, tuning interactions between amplifier stages, variation of input and output impedances, and thus of transducer gain, with changes in source and load impedance. All these problems could be obviated by unilateralizing the transistor. The difficulty with unilateralization at the present time is that with a small number of components unilateralization can be achieved only over a narrow frequency range and even there depends on temperature and changes in the supply voltage. Thus it does not appear feasible to integrate the unilateralization network into the transistor unless one knows the specific application. In such a case one would not end up with a universally useful device. Integration, however, seems to offer an answer to the problem. First, one could use a larger number of components to unilateralize since in the thin-film technique they would not occupy much space. Second, one could simulate the distributed properties of the transistor equivalent circuit (which one must do to balance the internal feedback of the transistor) by depositing into the integrated structure not lumped but also distributed components. Third, one could attack the dependence of the degree of unilateralization on the bias voltage by using not the standard fixed capacitors but variable capacitors with the same voltage dependence as the transistor collector capacitance. Thus it appears possible to develop in the integrated circuitry technique a self-biasing transistor structure which is unilateral over a wide range of frequencies and operating voltages. Since this can be done without much loss in power gain (theoretically the unilateralized gain in some cases may even be higher) the advantages of such a device from the standpoint of the simplicity of circuit design are obvious.

Similar remarks hold for wide-band amplifiers. Again one could develop a wide band amplifier stage which has uniform power gain and constant input and output impedances over the entire pass band. The neutralization network which compensates for the drop of current amplification at high frequencies (i.e. reduces the current gain at low frequencies), and which compensates for the shift in input and output impedances, could be deposited into the transistor structure yielding an iterative wide-band amplifier stage, any number of which could be cascaded to form a multiple stage amplifier.

Tuned circuits, like tuned amplifiers and oscillators, present certain problems at the present time because a suitable solid state inductance of high *Q* has not yet been developed to be compatible with the thin-film approach. In oscillator circuits one has the possibility of building phase-shift oscillators without inductance but it does not appear feasible to eliminate the inductance in all applications. Initial work on the solid state inductance has started. One knows, for example, that the input impedance of a transistor is inductive in certain frequency ranges and that the *Q* of a circuit can be enhanced by inserting a negative resistance. A workable device, however, has apparently not yet been developed.

Pulse circuits for computer applications with their nigh repetitiveness, of course, are particularly attractive for the new technique, and multivibrators have been constructed using thin-film techniques. Logic circuits, shift registers, etc., are all within immediate realizability.

Obviously integration is not restricted to *p-n-p* or *n-p-n* transistor circuits but applies to the entire gamut of new semiconductor devices.[2] *PNPN* and other multiple-junction structures with their interesting switching properties, multiple diode arrays, active diodes, unipolar devices, semiconductor delay lines will all find a place where they perform a required function more efficiently than other circuits.

So far we have talked mostly about those circuits

[2]See J. T. Wallmark, Integrated Electronic Devices, 1958-1959 Research and Development Handbook, N. Y.

or parts of circuits which might most effectively be integrated, using essentially the concepts of conventional circuitry. Integration and microminiaturization, however, have their own specific circuit and device-design problems on which we also want to touch here. The extremely small structures envisioned in the new approach make it difficult to remove heat generated in the device due to dissipation, and since excessive overheating cannot be allowed (in particular because of the semiconductor devices used) the internal heat generation must be kept at a minimum. Various approaches appear feasible. When the signal level can be chosen, as in many computer applications, it should be kept as low as possible. In other circuits the desired function should be performed with a minimum of *d-c* supply power. This calls for the design of transistors which operate satisfactorily at very low levels of *d-c* emitter current and collector voltage. Since the drop in current amplification at low emitter current levels (in particular with silicon) has been traced to recombination in the emitter junction and has been successfully counteracted in some cases, such transistors appear feasible. Another approach would be to try to develop an integrated circuit using two transistor-like structures in high-efficiency class B or A-B operation with sufficiently low distortion. Furthermore, it appears desirable to develop transistors with a very low temperature dependence of their fourpole parameters so that the external stabilization even over wide temperature ranges can be minimized, thus reducing the power dissipation in the bias network. All these characteristics would not only alleviate the heat removal problem of microminiaturized building blocks but would also reduce the *d-c* power requirement of the overall equipment which obviously is of extreme importance in military applications.

Another problem to be tackled stems from the fact that due to the essentially two-dimensional geometry of the new structures, the surface-to-volume ratio is high, and furthermore, many electronic functions are performed right on the surface. Semiconductor surfaces, however, exhibit instability which may be detrimental to the reliability of the new devices and a concentrated effort in surface passivation appears to be a necessary supporting activity.

The minute separation of signal paths in the microminiaturized device presents the problem of interaction at high frequencies and careful studies must be made as to the desirable geometry, arrangement of contacts and interconnections and necessary high frequency shields. This question together with the heat removal problem lead to form factor studies in general. The initial work is based on the wafer geometry for the individual device which is then stacked into cubes. For certain applications, however, it may turn out that a cylindrical or even co-axial geometry is preferable.

The major problem confronting the entire concept of micro-miniaturization is reliability. Modern weapons systems contain such a large number of components and building blocks that the reliability of the individual unit must be extremely high to insure successful operation of the entire system.[3] Since microminiaturized devices will make it possible to build systems of much higher complexity, reliability of the individual building block cannot be stressed sufficiently. On the other hand one would expect offhand that if one combines several components into a single device, the failure rate of the assembly will be the product of the failure rates of the individual components, and yield and reliability will drop inversely. There is no question that this problem is serious. Pretesting of parts of the final assembly, such as the transistors is only an intermediate step because eventually the entire device will have to be manufactured in one shot. Other features of the new approach help. The failure rate of four resistors deposited simultaneously will be much lower than the failure rate of four resistors deposited individually. In other words because of the interdependence and casual relationships between the manufacturing processes of the various parts in an integrated device, the ordinary rules of composite reliability do not hold and the reliability of the integrated circuit may be higher than that of its conventional counterpart. The yield, too, should eventually be rather high, and just like reliability, will increase with increasing production volume. After all, an integrated circuit is still simpler than for example, a modern complex receiving tube.

A common opinion in industry is that reliability decreases with the size of the component. This author does not know how well founded this rule of thumb is but there is another factor which seems to easily counterbalance this possible disadvantage of small size. The care in the manufacturing and subsequent protection of semiconductor devices such as transistors is far superior to what is customary in the ordinary components field and for some time transistors have proven very reliable in conventional circuits. This superior technique of material processing and device construction will now be applied across the board to all components and should lead to a decisive increase in overall reliability. The small size of the new integrated components will probably make the material costs negligible and in addition will allow the simultaneous preparation of a large number of devices so that even with an initially lower yield the price of the end item may not be very high.

There are still other ways to approach the reliability problem. Complexity, unless coupled with redundancy, reduces reliability so that circuit simplification must be one of the prime objectives in the design of the integrated device. How this can be achieved depends on each individual case. Sometimes it may turn out that a relatively complex function performed by passive components may be done relatively easily with an active component which is neither bigger

[3]See e.g. Dana A. Griffin, What Price Unreliability, Missile Design and Development, Feb. 1959, p. 24.

nor more expensive, and whose power requirement may be less than that of lossy passive components.

Redundancy, of course, is always a remedy in reliability cases and with the small size of the future devices, may become increasingly practical. Nevertheless, extreme emphasis must be placed on the reliability of the individual device.

The first steps in the new direction will certainly fall short of the ultimate goal and it will, therefore, be necessary to allow for liberal tolerances and even drift in the performance characteristics of the integrated circuits in systems. Computer and other pulse circuits where the requirements are not so tight as in communications applications may therefore turn out to be the first proving ground for the new concepts.

This partially answers the question as to which type of circuits should be miniaturized first. The precise answer is determined from equipment and system surveys conducted by various groups in the military and commercial fields. Obviously the circuits which occur most frequently and whose miniaturization would therefore lead to the most drastic size reduction in equipment will be integrated first.

Other areas of importance, but not under as active a consideration as those mentioned so far, are power and very high frequencies. Obviously micro-miniaturized systems will be required to energize end organs which will take a certain amount of power so that it will be necessary to develop power amplifiers somewhat larger than the integrated devices but still compatible with them and capable of handling the required amount of output power. High efficiency of such stages in addition to their form factor will be a prime consideration. The microwave area is still relatively untouched by the new concept because of the physical size of wave guide and the poor success with solid-state microwave power sources so far. Nevertheless the spectacular accomplishments of very low noise amplification with solid state parametric devices may have a bearing on integrated circuitry at lower frequencies where similar concepts may be introduced.

So far we have discussed the re-design and integration of conventional circuits with certain modifications made possible or necessary by the new concept. In this area a large amount of work is being performed or has been proposed, and success in the near future is virtually guaranteed. The true field of microminiaturization and molecular electronics as defined in the beginning, however, takes us one step further into the lesser explored and more speculative areas of solid state physics. New effects, new technology, new ways of achieving amplification will be considered. A few areas of investigation where important contributions may be expected can already be listed:

P-N junctions have not yet been fully explored. High-field effects in junction depletion layers, controlled recombination in junctions, tunnel effects etc. appear as promising fields of exploration.

The carrier transport properties of thin films, single or polycrystalline, will be investigated for possible negative resistance or inductive effects. Research on semiconductor surfaces may lead to novel ways to perform electronic functions within, let us say, 1 mil of the surface which would be particularly attractive in view of the present wafer-like geometry of the integrated circuits. Piezoelectric, magnetostrictive and magnetic materials will be used in the new circuits wherever they lead to simplification. The Hall effect and magnetoresistance in semiconductors has already been used to build specialized devices.

Stimulated emission of electromagnetic radiation as obtained from solid-state masers may find use in certain systems, and the general exploration of electron and nuclear spins is extremely active at present and is bound to lead to additional applications. Ferrites and garnets hold high promise of increasing their electronic usefulness. Cyclotron resonance has variously been proposed as a means for obtaining amplification although the low-temperature requirement, as in the case of the present solid state masers, is a definite drawback in ordinary communications applications. Thermoelectric, thermomagnetoelectric and optical effects in semiconductors are also in a general exploratory stage.

Research on new semiconducting and other solid state materials, and even liquids and gases will certainly lead to new, yet unknown approaches. Particular emphasis in this area will be on the preparation of single crystals of a purity and perfection comparable to those reached in germanium and silicon today. Only then can one hope to obtain the control necessary for reproducibility and reliable operation. Furthermore, it may turn out that these high-grade crystals have different properties than those of the presently known forms of the various materials which may lead to novel applications. An accelerated program in material synthesis therefore seems extremely important to promote rapid advances in the yet unexplored and more speculatory areas of physical electronics. The great shortage of inorganic synthetic chemists in the United States (as in most other countries) will undoubtedly present a major bottleneck in any such efforts.

It is obvious from what has been said above that the New Trend in Electronics essentially means a broad and intense effort in Physical Electronics. The terms Molecular or Atomic Electronics seem pertinent whenever the specific properties of the molecule or atom, or phenomena on a molecular or atomic scale are essential to the electronic function performed by the device. When the emphasis is on size reduction the terms Micro-Miniaturization and "Milli-Micro-Miniaturization" (Philco Corporation) and ultimately "Angstronics" (U. S. Army)[4] have been applied. In revolutionary times such as these it is, of course, unavoidable that certain words become associated with

[4]Suggested by Col. L. J. D. Rouge, Director, Electronic Components Research Dept., U.S. Signal Res. and Dev. Laboratory, Ft. Monmouth, N.J.

certain fads, regardless of their actual meanings; but fortunately, it is only the terminology which seems somewhat confused at the present time.

We may now ask ourselves what are the implications of the New Era in Electronics for the industry and for electrical engineering in general. The structure of electronic companies will be affected to an increasing degree as the new concepts find more widespread application. As systems will be composed directly of system and circuit-function components, the need for circuit design and assembly will decrease, and integrated device development and production will gain prime importance. The emphasis will be on solid state technology; rapid developments and rapid obsolescence will pose additional problems. Large companies will most likely attempt to master all pertinent types of technology and use them in a system of highly flexible automation. Small companies concentrating on novel and special techniques will remain competitive because of rapid advances in this field and the need for and possibility of building a great variety of specialized devices, for which the military and the entertainment, automotive and appliance industries will provide a steady market.

The implications for the electrical engineer are important. The continuous application of new effects puts a tremendous strain on the development engineer who has no firm guidelines to work by as in tube or conventional transistor circuitry. Rather, he will be guided by his general knowledge of electronics and solid state physics. The "cook book" engineer will disappear and the training of electrical engineers will undergo important changes. A thorough introduction to solid state physics will be part of every E.E. curriculum. The need for the circuit designer as such will decrease and the individual with a thorough physics training in addition to his electronics background will be the key man in future electronics development departments. The increased requirements will undoubtedly influence the salary structure for such positions. All in all the new trend is greeted with enthusiasm by electronic engineers who see in it an interesting stimulation away from routine work and a big challenge to contribute significantly in a novel and unorthodox approach to electronic problems.

There can hardly be a doubt that exciting times are ahead for the semiconductor field and for solid state electronics in general.

. . . . . *a special message*

This issue marks the close of the 2nd year of publishing SEMICONDUCTOR PRODUCTS. It's been an exciting two years and it's only the beginning! We look forward to many years of bringing the fast-moving and ever-growing semiconductor industry bigger and better issues of their magazine . . . SEMICONDUCTOR PRODUCTS! On the occasion of our 2nd Anniversary we want to thank all our readers, our friends and associates in the industry for their encouragement and support. And, we also wish to take this opportunity to extend Season's Greetings and a Happy and Prosperous New Year!

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SEMICONDUCTOR & SOLID-STATE BIBLIOGRAPHY

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHOR
Self-Diffusion in Indium	Acta Metallurgica May 1959	Self-diffusion coefficient parallel and perpendicular to the tetragonal axis were measured in paired samples of single-crystal indium in the range from 44° to 144° C.	J. E. Dickey
Two Terminal *p-n-p-n* Switches	Bell Labs Record June 1959	Operating principles, features and applications are described.	J. M. Goldey
World Trends in Semiconductor Development and Production	Brit Comm & Elecncs June 1959	This article surveys contributions that have been made to the development and production of semiconductor devices.	C. C. Gee
High Frequency Tetrode Transistors	Brit Comm & Elecncs June 1959	Origin, theory of operation, and manufacturing technique discussed; applications in wide-band *r-f* video and *h-f* amplifier circuits.	J. T. Kendall J. S. Walker
Components for Use With Transistor Techniques	Brit Comm & Elecncs June 1959	Review of components used with transistors. Problems of soldering components and accessibility for servicing are discussed.	G. W. A. Dummer
Measurement of Transistor Parameters Using Bridge Techniques	Brit Comm & Elecncs June 1959	Use of a 3-terminal bridge has been found to be an excellent method for determining transistor matrix parameters; explanation is given on measurements up to 30 *mc*.	M. J. Gay
Statistical Theory of Avalanche Breakdown in Silicon	Canadian Jl of Phys June 1959	Current flow under conditions of high electric field sufficient to cause avalanche breakdown is discussed, and a statistical model presented.	R. E. Burgess
Solid-State Circuitry	Control Engineering June 1959	Interpretive report on status of solid-state developments from the viewpoint of the control engineer.	E. J. Kompass L. H. Young
Fundamentals of Multivibrators—9	Control Engineering June 1959	Description of a selected group of multivibrator circuits include vacuum-tube and transistor devices.	E. Keonjian W. Perzley
Secondary Effect of Diode Leakage in Selection Matrices	Electronic Design June 10 1959	A simple modification of multiple level switching circuits will guarantee consistent operation.	I. N. Saxe M. Collins
Thermal Considerations in the use of Power Transistors	Electronic Design June 10 1959	Design principles are outlined together with relative results for different schemes; a practical approach to thermal dissipation problems.	J. R. Baum
Transistor Hybrid Timing Circuit	Electronic Design June 24 1959	One unijunction and two junction transistors are combined to provide highly desirable multivibrator characteristics.	T. P. Sylvan
A Transistor Characteristic Curve Tracer	Electronic Eng (Br) June 1959	A Dekatron is used to develop a stepped voltage controlling the base current of the transistor under test.	J. F. Young
The Design of Biased Diode Function Generators	Electronic Eng (Br) June 1959	Equations are derived relating the number of diode sections, and the construction of a sine function generator is detailed.	C. C. Ritchie R. W. Young
Network Functions	Electronic Equip Eng June 1959	Network coefficient, transfer functions, and system functions are defined and explained; an incremental transistor equivalent circuit of an amplifier is used.	R. B. Hurley
Design of Transistor Packages for Digital Systems	Electronic Equip Eng June 1959	Assortment of novel circuits for application in digital systems ranging from a simple data converter to a complex computer.	R. F. Shaw
Novel Output Coupling for Servo Amplifiers	Electronic Equip Eng June 1959	Output remains sinusoidal, even if input signal is many times that required for normal output; clipping is avoided.	A. D. Evans
Design for a High-Voltage Power Supply	Electronic Equip Eng June 1959	Single-transistor Hartley oscillator provides *d-c* output voltage up to 1000 volts for measuring resistance up to 5000 million megohms.	W. W. Hartz
Performance and Cost in Transistor Design	Electronic Equip Eng June 1959	Various design elements are analyzed with respect to cost factors reflected by process complexity, product reproducibility and design flexibility.	S. O. Johnson
Design of a Solid State Timing Module	Electronic Equip Eng June 1959	Transistor circuitry allows development and manufacture of subminiature timing devices of high accuracy and reliability.	A. M. Multari
How to Design for Transistor Reliability-IV	Electronic Equip Eng June 1959	Discussion of circuit performance margins, degradation, specification, overall test, and special problems.	J. B. Hangstefer I. H. Dixon Jr.
Design for VHF Power Stages	Electronic Equip Eng June 1959	Complete data on input and output networks for transistor amplifier and oscillators for operation at 200 and 400 mc using common-base configurations.	R. R. Webster
Millimicrosecond Switching Diodes	Electronics June 5 1959	Outdiffusion technique produces fast-switch diodes. Article discusses forming of junction and switching speed.	J. Halpern R. H. Rediker
Tube-Transistor Hybrids Provide Design Economy	Electronics June 5 1959	Design technique is described for combining transistors and vacuum tubes in a single circuit. Advantages discussed.	G. A. Dunn N. C. Hekimian
Sending Digital Data Over Narrow-Band Lines	Electronics June 5 1959	Transistorized wire-line terminal unit transmits and receives binary data at to 2,500 bits/sec in a nominal 3 *kc* voice-band circuit.	J. H. Hollis
Taking the Heat Off Semiconductor Devices	Electronics June 12 1959	Factors, equations, charts and nomograms needed to tailor a fin to a power transistor or diode without involved math.	W. Luft
Designing High Quality A-F Transistor Amplifiers	Electronics June 12 1959	Description of completely transistorized audio amplifier using junction transistors to deliver 25 watts output power.	R. Minton
Using Silicon Diodes in Radar Modulators	Electronics June 12 1959	Discussion of radar modulator with peak power of 250 *kw* that uses silicon diodes to replace vacuum tubes.	M. G. Gray
One-Transistor "Push-Pull"	Electronics June 12 1959	Output circuit uses single transistor to approximate push-pull class-B audio output. No input transformer needed.	J. A. Worcester
Circuits for Space Probes	Electronics June 19 1959	Transistorized circuit design allows use of vehicle as space station relay for long-distance VHF communications.	R. R. Bennett G. L. Gleghorn L. A. Hoffman M. G. McLeod Y. Shibuya

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHOR
Switching VHF Power with Silicon Diodes	Electronics June 19 1959	Silicon power rectifier diodes, placed in a coaxial cable, switch *r-f* power from one circuit to another.	R. H. Matson S. H. Lin
Thermoelectric Properties of Semiconductors	Electronics June 19 1959	Ten well-known semiconductors are presented in convenient table that shows comparative characteristics.	D. A. Wright
Transistor Rectifier Gives *D.C.* of either Polarity	Electronics June 19 1959	Diagonally symmetrical power transistor circuit permits smooth load current variation over range of several amperes.	R. R. Bockemuehl
Semiconductor Devices for Microminiaturization	Electronics June 26 1959	Devices are built with a packing density of 10^8 parts per cubic foot. Method of use in logic circuits explained.	J. T. Wallmark S. M. Marcus
Detecting Low-Level Infrared Energy	Electronics June 26 1959	Multiple-cell infrared detectors have increased sensitivity compared to single-cell systems and require less optical-mechanical equipment.	H. Dubner J. Schwartz S. Shapiro
Transistorized Radar Sweep Circuits Using Low Power	Electronics June 26 1959	High duty factor ppi sweep circuit features efficient and simple gated clamp, linear peak to peak *d-c* amplifier, and silicon transistors to prevent thermal runaway.	C. E. Veazie
Thermocouple Errors During Temperature Transients	Industrial Labs June 1959	Curves are presented from which the magnitude of this error may be readily evaluated for the specific case.	D. P. Timo
The Physics of the Solid-State Maser	IRE Trans Comp Parts June 1959	General theory of emission and radiation processes. A quantum mechanical description is employed as it applies to the investigation of transistors between energy levels.	D. J. Howarth
Integrated Devices Using Direct-Coupled Unipolar Transistor Logic	IRE Trans Elec Comp June 1959	Advantages of unipolar transistors. Description of extremely miniaturized device given. Integration of passive components into semiconductor devices.	J. T. Wallmark S. M. Marcus
P-N-π-N Triode Switching Applications	IRE Trans Elec Comp June 1959	The characteristics and switching applications of a developmental diffused silicon *p-n-π-n* triode are discussed.	V. Grinich I. Haas
Radio Telemetering from Within the Human Body	IRE Trans Med Elec June 1959	Transistorized units small enough to be introduced into the bladder, or to be swallowed—a summary of recent developments and future outlook.	R. S. Mackay
Short-Distance Radio Telemetering of Physiological Information	IRE Trans Space E & T June 1959	A completely transistorized radio transmitter and a receiving system operating at 104 *mc* are described.	H. G. Beenken F. L. Dunn
A Super-Fast, Carrier Quieted, Telemetry System for Missile Impact Instrumentation	IRE Trans Space E & T June 1959	Transistorized system measures, to one microsecond, the time between events during the sled test destruction of an impacting missile.	J. L. Wright J. C. Ruscus
Asymmetric Hysteresis Loops and the Pyroelectric Effect in Barium Titanate	J1 App Phys June 1959	Studies of single crystal $BaTiO_3$ reveal asymmetric hysteresis loops with respect to both the polarization and electric field axes.	R. C. Miller A. Savage
Interdiffusion in Binary Ionic Semiconductors	J1 App Phys June 1959	Investigations have been made using the theory for the concentrations of defects in crystals and Wagner's phenomenological flow equation.	R. F. Brebrick
Temperature Dependence of Fractional Velocity Changes in a Silicon Single Crystal	J1 App Physics June 1959	An ultrasonic interferometer technique for measuring the temperature dependence of the relative change in elastic constants is described in detail.	F. Stein N. G. Einspruch R. Truell
Drift Velocity Saturation in *p*-Type Germanium	J1 App Physics June 1959	A method of making an ohmic contact to a semiconductor that does not inject minority carriers at high current densities has been found.	R. D. Larrabee
X-Ray Measurement of Microstrains in Germanium Single Crystals	J1 App Physics June 1959	Structural defects in a crystal cause some of the atoms to deviate from their normal locations in perfect planes. These atoms will no longer be at the nodes of the X-ray wave field.	L. P. Hunter
Anisotropic Mobilities in Plastically Deformed Germanium	J1 App Physics June 1959	The carrier density as a function of temperature in *n*-type germanium has been measured during plastic deformation by bending.	R. A. Logan G. L. Pearson D. A. Kleinman
Electromechanical Behavior of Single Crystals of Barium Titanate from 25° to 160°C	J1 Applied Physics June 1959	Dynamic piezoelectric resonance measurements have been made on single crystals of barium titanate from room temperature to 160°C.	E. J. Huibregtse W. H. Bessey M. E. Drougard
Effect of Variations in Surface Potential on Junction Characteristics	J1 Applied Physics June 1959	These variations are considered in terms of simple theory, and device implications are discussed.	J. H. Forster H. S. Veloric
Proportionality between Photoconductance and Time Constant in Lead Sulfide Films	J1 Applied Physics June 1959	The ratio of signal to the product of resistance and time constant is useful in interpreting data taken on films whose properties are changed by ambient conditions.	H. E. Spencer
InAs and InSb as Thermoelectric Materials	J1 Applied Physics June 1959	Measurement of the electrical conductivity, thermal conductivity, and Seebeck coefficient (thermoelectric power) have been made at high temperatures.	R. Bowers R. W. Ure Jr. J. E. Bauerle A. J. Cornish
The Application of Magnetic Resonance to Solid State Electronics	Jl Brit IRE June 1959	Basic principles and techniques of magnetic resonance; four recent applications discussed.	D. J. E. Ingram
Adsorption of Hydrogen in Silicon	J1 of Chem Phys June 1959	The adsorption of both atomic and molecular hydrogen on silicon films and single crystals has been studied.	J. T. Law
Solubility of Carbon in Silicon and Germanium	J1 of Chem Phys June 1959	The solubilities have been measured, (and phase diagrams presented) for appropriate temperature ranges and pressures.	R. I. Scace G. A. Slack
A New Separator for the Aluminum Dry Cell	J1 Electrochem Soc. June 1959	The separator described provides an adhesive contact with the anode and a satisfactory electrolytic contact with the cathode.	N. C. Cahoon M. P. Korver
On the Internal Resistance of Dry Cells	J1 Electrochem Soc. June 1959	Measurements were made by imposing a current pulse on the cell and observing the instantaneous IR drop in the cell.	R. J. Brodd
Iodine-Activated Solid Electrolyte Cell for Use at High Temperature	J1 Electrochem Soc. June 1959	Miniature cells with solid silver iodide as the electrolyte have been studied at 150°—155°C. The size of the smallest cell is 0.15 cm D and 0.5 cm in length.	J. L. Weininger

TITLE	PUBLICATION	CONDENSED SUMMARY	AUTHOR
Chemical Etching of Silicon. The System HF, HNO_3, and H_2O	J1 Electrochem Soc. June 1959	The kinetics of the etching of silicon in the system HF, HNO_3, and H_2O was studied as a function of the composition of the etchant at 25° C.	H. Robbins B. Schwartz
Preparation of Crystals of InAs, InP, GaS, and GaP by Vapor Phase Reaction	J1 Electrochem Soc. June 1959	Small crystals have been grown from a vapor composed of the monochloride or monoiodide of the metal and phosphorus or arsenic.	G. R. Antell D. Effer
Electron Characteristic Energy Losses in Some Intermetallic Compounds	Physical Review June 1 1959	Measurements have been made of the characteristic energy losses of 30-kev electrons in transmission through thin films of indium antimonide, cadmium telluride, and zinc telluride.	B. Gauthe
Electron Spin Resonance Experiments on Donors in Silicon I.	Physical Review June 1 1959	Electronic structure of donors by the electron nuclear double resonance technique. The ground-state wave function of antimony phosphorus, and arsenic impurities in silicon have been investigated.	G. Feher
Electroluminescence of AlN	Physical Review June 1 1959	Electroluminescence in the visible region is observed when AlN is excited by either *a-c* or *d-c*.	G. A. Wolff I. Adams J. W. Mellichamp
Electron Spin Experiments on Donors in Silicon	Physical Review June 1 1959	Electron spin relaxation effects the different relaxation processes that connect the four energy levels in phoshorus doped silicon have been investigated experimentally.	G. Feher E. A. Gere
Temperature Dependence of the Electrical Properties of Bismuth-Antimony Alloys	Physical Review June 15 1959	The electrical resistivity and Hall effect of zone-levelled single crystals of Bi-Sb alloys have been measured in the temperature range from 4.2°K to 300°K.	A. L. Jain
Optical Properties of Nickel Oxide	Physical Review June 15 1959	The absorption spectrum of single crystal NiO has been measured in the 0.1 to 6 ev range, and its reflectivity spectrum from 0.025 to 10 ev.	R. Newman R. M. Chrenko
Physical Principles of Avalanche Transistor Pulse Circuits	Proceedings IRE June 1959	A simple physical theory is developed which permits a calculation of the significant points of avalanche transistor transient behavior.	D. J. Hamilton J. F. Gibbons W. Shockley
Pulse Amplification Using Impact Ionization in Germanium	Proceedings IRE June 1959	Some aspects of the phenomena of impact ionization in an impurity-doped semiconductor at 4.2°K are described.	M. C. Steele L. Pensak R. D. Gold
Surface-Immune Transistor Structure	RCA Review June 1959	A new transistor structure is described in which the base region is brought to the surface through the central region of the collector.	H. Nelson
Semiconductor Diodes in Parametric Subharmonic Oscillators	RCA Review June 1959	In this paper the performance of semiconductor diodes in the basic oscillator circuit is evaluated.	J. Hilibrand W. R. Beam
Stabilization of Transistor Gain over Wide Temperature Ranges	RCA Review June 1959	The effects of junction-temperature variations on the *a-c* stability of an amplifier are analyzed in terms of the temperature dependence of the hybrid-π equivalent-circuit parameters.	R. A. Schmeltzer
Some Stability Considerations in the Design of Large Feedback Junction Transistor Amplifiers	Semiconductor Prod June 1959	Justification of an approximate transistor equivalent circuit suitable for design of amplifier circuits having large amounts of feedback.	H. Hellerman
Static Characteristics of Transistors	Semiconductor Prod June 1959	Effects of various voltage and current parameters are described and illustrated by nine sets of characteristic curves for the basic transistor configuration.	A. W. Carlson
Studies of Semiconductor Materials Using a Vacuum Microbalance	Semiconductor Prod June 1959	Studies of sputtering, oxidation, and surface regeneration phenomena, as well as other applications of the microbalance are discussed.	S. P. Wolsky
The Growing Role of Graphite in the Semiconductor Processing Industry	Semiconductor Prod June 1959	Properties and characteristics of graphite discussed with relation to its use in the semiconductor industry.	W. E. Allsopp
Developmental Transistors for VHF and UHF	U. S. Govt Res Reports June 12 1959 LC $6.30 PB 137 301	Current status (Mar. 1, 1957) of developmental diffused-base germanium transistors, and the potential of these devices for oscillator amplifier work.	V. Boxer
Analysis and Design Transistor Video Amplifiers	U. S. Govt Res Reports June 12 1959 LC $3.30 PB 137 380	The analysis of a single stage amplifier is carried out based on the Giacoletto equivalent circuit. Four methods of exchanging amplification and bandwidth are described.	T. A. Prugh
High-Speed Graded-Base-Transistor Switching Circuits	U. S. Govt Res Reports June 12 1959 LC $4.80 PB 139 204	GB transistors of the *p-n-p* type were incorporated into various switching circuitry designs, and indicate that they are well suited for deriving high power gains at high frequencies.	R. H. Baker E. J. Chatterton Jr. A. C. Parker
Statistical Study of Transistor High-Frequency Equivalent Circuits	U. S. Govt Res Reports June 12 1959 LC $13.10 PB 136 433	Considerations on the simple equivalent circuit serving as a link between transistor device parameters and quadruple parameters often sought by circuit designers.	R. L. Walker
Transistor Measurements Using the Indefinite Admittance Matrix	U. S. Govt Res Reports June 12 1959 LC $6.30 PB 136 434	A method is shown whereby four measurements made directly on commercial bridges may be used to find the admittance parameters in any orientation.	J. P. Paddock
Industrial Preparedness Study: Transistor Manufacturing	U. S. Govt Res Reports June 12 1959 LC $9.30 PB 137 161	Report on contract, the purpose of which is to establish production design of devices and to establish manufacturing techniques for pilot production.	C. Huang
Investigation on Utilization of Radio-Active Energy as a Source of Battery Power	U. S. Govt Res Reports June 12 1959 LC $10.80 PB 139 279	Modifications are described for reducing the temperature coefficient of voltage, Tritium was considered the most promising isotope for use in the gaseous conization CPD type of nuclear battery.	T. Thomas I. Di Bello
Investigation of the Applications of Negative Resistance Diodes for Switching Circuits	U. S. Govt Res Reports June 12 1959 LC $9.30 PB 137 830	An attempt is made to search deeply into the various characteristics and to simulate negative resistance devices using transistor combinations.	Transistor App. Inc.
Investigation of the Applications of Negative Resistance Diodes for Switching Circuits	U. S. Govt Res Reports June 12 1959 LC $6.30 PB 139 220	Various measurements of characteristics as functions of circuit and environmental conditions are investigated.	Transistor App. Inc.

PATENT REVIEW*

Of Semiconductor Devices, Fabrication Techniques and Processes, and Circuits and Applications

Compiled by SIDNEY MARSHALL

The abstracts appearing in this issue cover the inventions relevant to semiconductors from Mar. 26, 1957 to May 7, 1957. In subsequent issues, patents issued from Dec. 25, 1956 to date will be presented in a similar manner. After bringing these abstracts up to date, PATENT Review will appear periodically, the treatment given to each item being more detailed.

March 26, 1957

2,786,880 Signal Translating Device—K. G. McKay. Assignee: Bell Telephone Laboratories. In combination, an electric discharge tube including a body of impurity-type semiconductive material, a collector electrode comprising a metal film covering a portion of the body and a barrier layer juxtaposed to said film and separating said film from said base electrode.

2,786,964 Headlight Dimmer System—H. DeWitt, H. Sandler, R. C. Wittenberg. Assignee: Radio Receptor Co., Inc.; A transistorized automatic vehicular headlight dimming system.

April 2, 1957

2,787,564 Forming Semiconductive Devices By Ionic Bombardment — W. Shockley. Assignee: Bell Telephone Laboratories. A method of treating a semiconductor body by bombarding an area thereof with a beam of ions of a significant impurity element having a penetration energy such that a zone of conductivity type opposite from that of the body will be formed in the interior of said body.

2,787,712 Transistor Multivibrator Circuit—H. F. Priebe Jr., A. E. Spencer Jr. Assignee: Bell Telephone Laboratories. A circuit designed to free the rise time of the output voltage wave-form produced by a transistor multivibrator or binary counter from dependence on circuit parameters as opposed to transistor parameters.

2,787,717 Transistor Pulse Delay Circuit—B. Kasmir. Assignee: Emerson Radio & Phonograph Corporation. In a pulse delay circuit using a transistor means for producing alternate normal and trigger induced pulses in the emitter circuit and corresponding square wave voltage pulses in the collector circuit, and means for varying the time interval between a collector trigger pulse and the following collector normal pulse.

2,787,744 Temperature Stabilized Transistor—R. L. Brock, J. E. Maynard, R. C. McCarthy, T. N. Ross. Assignee: Boeing Airplane Company; A liquid cooled transistor comprising an encompassing jacket, a transistor supported within said jacket, and a liquid having molecules free of polar electric moment, said liquid being contained within said jacket.

2,787,745 Counter-Electrode For Dry Disk Type Rectifiers—H. K. Stroche, O. J. Klein. Assignee: International Standard Electric Corporation. A counter electrode for a selenium rectifier, said electrode consisting of a metal of the secondary group of the fourth and fifth groups of the periodic system, and an additive from the group comprising thallium, indium and gallium.

2,788,298 Methods of Growing Crystals And Making Electrical Translators—E. N. Clarke. Assignee: Sylvania Electric Products Inc. A method of germanium crystal growing consisting of growing a crystal out of a melt, during which operation impurities in the melt tend to separate from the growing end of the crystal, removing said crystal from the melt with a molten layer of impurity containing material at its end, and making desired electrical connections to the crystal after solidification has taken place.

April 9, 1957

2,788,299 Method of Forming Junction Transistors—M. H. Dawson. Assignee: Sylvania Electric Products Inc. A method of producing a junction transistor by subjecting a wafer of n-type germanium having polished and etched faces to treatment at 650°C at a pressure more than 10^{-4}mm. Hg. for about 3 hours, assembling said wafer with said faces in engagement with opposed dots of indium, and repeating the high temperature-low pressure treatment.

2,788,300 Processing of Alloy Junction Devices—M. H. Dawson. Assignee: Sylvania Electric Products Inc. A method of forming and treating electrical rectifying alloy junctions by immersing a germanium-alloy terminal assembly in a molten mixture of potassium and sodium cyanide.

2,788,381 Fused Junction Semiconductor Photocells—E. M. Baldwin. Assignee: Hughes Aircraft Company. A semiconductor photocell in which the collector junction is placed close to the impinging radiant energy to give greater light collection at the photosensitive area.

2,788,431 Welding Apparatus For Semiconductor Translating Device—F. Wohlman Jr. Assignee: Hughes Aircraft Company. Apparatus for securing a whisker to another element of a semiconductor translating device component, said apparatus providing means for supporting and aligning the various elements of the components, and for insuring effective electrical contacts between said elements of said components and a source of spot welding current.

2,788,449 Adjustable Multivibrator—R. L. Bright. Assignee: Westinghouse Electric Corporation. A circuit that provides an electrical pulse generator in which the relative duration of the positive and negative pulses may be varied over a substantial range by varying the magnitude of a d-c bias voltage.

2,788,474 Rectifier Assembly—J. A. Jackson. Assignee: Westinghouse Electric Corporation. An assembly comprising an insulating container, a plurality of rectifier cells supported therein, contact members making contact with certain cells, leads extending from said members, an insulating cover fitting the container, and a case enclosing the container and the cover.

2,788,475 Sealed Semiconductor Device—R. C. Ingraham. Assignee: Sylvania Electric Products Inc. A rectifying-contact device which can be manufactured by mass production methods and which can be readjusted or salvaged when necessary without detracting from the stability or the obtaining of desired semiconductor properties.

2,788,489 Phase Detecting System—J. M. Hollywood. Assignee: U.S.A. (Department of the Air Force). A phase detector which will produce an output which is a function of the phase difference between the two input signals and whose output is independent of the relative amplitude of the two input signals.

2,788,493 Modulated Semiconductor Oscillator Circuit—J. Zawels. Assignee: Radio Corporation of America. A modulated oscillator circuit utilizing semiconductor devices of opposite conductivity type in a balanced circuit arrangement wherein undesired distortion and intermodulation products are substantially eliminated.

April 16, 1957

2,788,068 Evaporation - Fuzed Junction Semiconductor Devices — J. Maserjian. Assignee: Hughes Aircraft Company. The method of producing an integral p-type regrown region upon a surface of an n-type silicon body.

*Source: Official Gazette of the U. S. Patent Office and specifications and Drawings of Patents Issued by the U. S. Patent Office.

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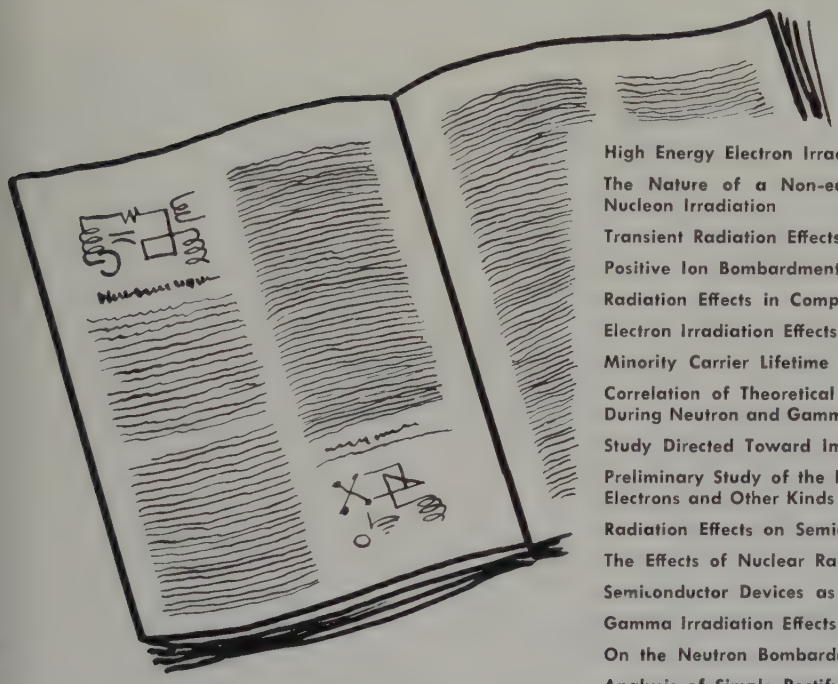

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2,789,153 Furnace For Producing Single Crystals For Transistors—A. Klark. Assignee: None. An electric furnace comprising an upright quartz tube including a reentrant well, a quartz crucible within said well, a graphite heater within said tube, a second around and spaced from said quartz tube, and means for exhausting gases and vapors from the furnace.

2,789,164 Semiconductor Signal Amplifier Circuit—T. O. Stanley. Assignee: Radio Corporation of America. A multistage translating circuit providing stabilized circuit operation with temperature variations, a balanced output current with a minimum number of circuit components, feedback means for stabilizing the operation of the circuit without signal degeneration.

2,789,214 Junction Transistor Superregenerative Receiver — W. A. Seargeant. A super regenerative receiver employing a junction transistor, said receiver having a grounded base circuit modulated by a lower frequency oscillator connected in a grounded emitter configuration, said lower frequency oscillator producing signals which periodically interrupt the oscillations of the high frequency oscillators.

2,789,257 Transistor—G. Van Donkersgoed, L. J. Tummers. Assignee: North American Phillips Company Inc.; A transistor comprising a semiconductive body, a base ohmic connection to said body, two rectifying connections to opposite sides of said body, one of said rectifying contacts fused to and diffused into said body producing a large area junction, the other rectifying connection making point contact with said body and producing a small-area junction.

2,789,258 Intrinsic Coatings For Semiconductor Junctions—C. G. Smith. Assignee: Raytheon Manufacturing Company. A semiconductive germanium or silicon body having a *p-n* junction therein, said junction being covered by a layer of intrinsic material of the same kind as said body.

April 22, 1957

2,790,033 Transistor Amplifier Circuit—F. P. Keiper Jr. Assignee: Philco Corporation. A semiconductor amplifier circuit in which, by adjustment of certain circuit parameter values, undesired interaction between the output and input circuits of the semiconductor elements can be eliminated to any desired degree.

2,790,034 Semiconductor Signal Translating Devices—K. B. McAfee. Assignee: Bell Telephone Laboratories. A device comprising a transistor body having an *n*-type zone contiguous with a *p*-type zone, means for introducing minority carriers into one of said zones and means for providing at the junction a reverse biasing electric field in excess of 10^5 volts/cm

2,790,037 Semiconductor Signal Translating Devices—W. Shockley. Assignee: Bell Telephone Laboratories. A device constructed so that in a particular region the donor acceptor unbalance is less than five percent of the number of thermally generated carriers at the operating temperature in ideally intrinsic semiconductive material of the kind forming the semiconductive body.

April 23, 1957

2,790,088 Alternating Current Gate—J. N. Shive. Assignee: Bell Telephone Laboratories. A gate circuit comprising a pair of input and output terminals, shunt connections including impedances between said input terminals and similar devices between said output terminals, and connecting means including a light sensitive semiconductor between one input and one output terminal.

2,790,089 Three Element Semiconductor Device—L. S. Pelfrye. Assignee: National Aircraft Corporation. A three-element device, an envelope surrounding the assembly, said envelope containing an inert gas, said device functioning during conduction through said gas between an electrode and a semiconductive body to bombard with light a point-contact region formed by said body and two other electrodes.

2,790,118 Three Element Semiconductor Device—C. W. Rhode, Assignee: National Aircraft Corporation. A base semiconductor subassembly which can be moved into contact with preset emitter and collector electrodes and which will remain in contact without being held by the assembler, until it is permanently locked to its support.

2,790,127 Regulated Rectifying Apparatus —B. H. Hamilton. Assignee: Bell Telephone Laboratories. Apparatus for regulating the rectified current supplied to a load to minimize changes of load voltage when the load current is within a normal operating range and for reducing the load voltage when the load current exceeds the normal operating current range.

2,790,135 Power Transmission—C. Bennett, L. W. Buechler. Assignee: Vickers, Inc. A polyphase bridge-type self-saturating magnetic amplifier in which the reactors in adjacent reactor branches are balanced with circulating current forced through an asymmetric circuit loop which includes, in series opposition, the power windings of the two reactors.

2,790,136 Power Transmission—C. Bennett, L. W. Buechler. Assignee: Vickers Inc. A polyphase bridge-type self-saturating magnetic amplifier, including a loop path having a unidirectional device, and windings inductively related to the two reactor power windings of adjacent reactor branches in opposition.

2,790,141 Semiconductor Measuring System—D. V. Geppert Assignee: Motorola Inc. A method for measuring the lifetime of excess minority carriers in a semiconductor.

April 30, 1957

2,790,856 Frequency Selective Transistor Amplifier—B. Birkenes. Assignee: Motorola Inc. A transistor intermediate frequency amplifier that includes a low impedance uptuned input circuit for each of the stages thereof, and a high impedance resonant output circuit for each of the various stages.

2,790,940 Silicon Rectifier nad Method of Manufacture—M. B. Prince. Assignee: Bell Telephone Labroatories. A rectifying element comprising a monocrystalline body of silicon less than ten mils thick and having along its thickness dimension an intermediate zone having low conductivity, a high conductivity first terminal zone contiguous with said intermediate zone, and a high conductivity zone contiguous with said intermediate zone and of opposite conductivity type to that of said first zone.

2,790,941 Terminal Lead Construction and Method, and Semiconductor Unit—J. W. Dawson. Assignee: Sylvania Electric Products Inc. A device comprising an envelope, a semiconductive element and a contact element within said envelope, one of said elements being carried solely by a terminal lead extending through a seal portion of said envelope, said seal comprising a glass member fixed to said envelope and to the lead.

2,790,952 Method of Optically Testing Semiconductor Junctions—W. J. Pietenpol. Assignee: Bell Telephone Laboratories. A method of determining the location of a point on a semiconductive surface in proximity to a junction by traversing a spot of light through said point and across said junction shading the point from the light, reproducing the photoelectric response of said surface as a function of distance along the light traverse, and measuring the separation from the response maximums of the pip in the response caused by the shading of the traverse.

May 7, 1957

2,791,524 Fabrication Method For P-N Junctions—V. Ozarow. Assignee: General Electric Company. A process that utilizes a mask of inert material in order to define an area on a semiconductor surface, said area being treated with a material from the class of donor and acceptor materials.

2,791,644 Push-Pull Amplifier With Complementary Type Transistors. G. C. Sziklai. Assignee: Radio Corporation of America. A semiconductor amplifier circuit capable of being connected directly to any undesired direct current to flow through the load, said amplifier being of the push-pull type and of a nature such that the amplifier devices are energized by signal voltages of the same instantaneous polarity and the output current is obtained directly.

2,791,645 Transistor Amplifier—C. E. Bessey. Assignee: U.S.A. (Department of the Army). A method for providing biasing means for transistors that will automatically compensate for changes in the operating conditions of the transistor.

2,791,691 Crystal Mounts—R. V. Pound N. F. Webster. Assignee: U.S.A. (Navy Department). Apparatus comprising a rectangular wave guide, a crystal rectifier mounted in said wave guide so as to present matched impedance with said waveguide at a given frequency, and a resonant iris placed at an odd number of quarter wavelengths from said crystal.

2,791,693 Stabilized Semiconductor Oscillator Circuits—R. P. Moore Jr. Assignee: Radio Corporation of America. A sine wave oscillator circuit in which changes in operational characteristics tend to cause cessation of oscillations, and in which amplitude and frequency variations due to ambient temperature variations are compensated for.

2,791,703 Semiconductor Device Having Focusing Electrodes—J. I. Pankove. Assignee: Radio Corporation of America. A transistor in which the electrodes are so disposed that the charge carriers injected by the emitter are substantially focused onto the collector while the carriers injected by the collector are substantially collected by the base.

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CHARACTERISTICS CHARTS OF NEW DIODES and RECTIFIERS

ANNOUNCED BETWEEN AUG. 1, 1959 and SEPT. 30, 1959 ONLY. This is a partial listing and will be continued in the next issue

MANUFACTURERS

AEG—	Allgemeine Elekticitats-Gesellschaft
AEI—	Associated Electrical Industries, Ltd.
AMP—	Amperex Electronic Corp.
AUD—	Audio Devices, Inc.
BEN—	Bendix Aviation Corp.
BER—	Berkshire Labs
BOG—	Bogue Electric Mfg. Co.
BOM—	Bomac Labs
BRA—	Bradley Labs
CBS—	CBS Electronics
CDC—	Continental Device Corp.
COL—	Columbus Electronics Corp.
CTP—	Clevite Transistor Products, Inc.
CSF—	Compagnie Generale de T.S.F.
EEVB—	English Electric Valve Co., Ltd.
ERI—	Erie Resistor Corp.
FAN—	Fansteel Mctallurgical Corp.
FERB—	Ferranti Ltd.
GAH—	Gahagan, Inc.
GECB—	General Electric Co., Ltd.
GE—	General Electric Company, Semiconductor Div.
GIC—	General Instrument Corp.
GTC—	General Transistor Corp.
HAFO—	Institutet for Halvedarforskning
HSD—	Hoffman Semiconductor Division
HUG—	Hughes Products Division
INRC—	International Rectifier Corp.
IRC—	International Resistance Co.
ITT—	International Tel. & Tel. Corp.
KEM—	Kemtron Electron Products, Inc.
LCTF—	Laboratoire Central de Telecommunications
MAL—	P. R. Mallory & Co., Inc.
MIC—	Microwave Associates, Inc.
MOT—	Motorola, Inc.
MUL—	Mullard, Ltd.
NAE—	North American Electronics
NPC—	Nucleonic Products Co., Inc.
OHM—	Ohmite Manufacturing Co.
PHI—	Philco Corp. Lansdale Tube Company
PSI—	Pacific Semiconductors, Inc.
QSC—	Qutronic Semiconductor Corp.
RAY—	Raytheon Company
RCA—	Radio Corporation of America, Semiconductor Div.
RHE—	Rheem Semiconductor Corp.
SAR—	Sarkes Tarzian, Inc., Rectifier Division
SCN—	Semicon, Inc.
SEM—	Semi-Elements Inc.
SIE—	Siemens & Halske Aktiengesellschaft
SIL—	Silicon Transistor Corp.
SSD—	Sperry Semiconductor Division
SSP—	Solid State Products, Inc.
STC—	Shockley Transistor Corp.
STCB—	Standard Telephone & Cables, Ltd.
SYL—	Sylvania Electric Products, Inc.
SYN—	Syntron Co.
TEX—	Texas Research Assoc.
TFKG—	Telefunken, Ltd.
THE—	Thermosen, Inc.
TI—	Texas Instruments, Inc.
TKD—	Tekade, Nurnberg, Germany
TOK—	Tokyo Tsushin Kogyo, Ltd.
TRA—	Transitron Electronic Corp.
TUN—	Tung-Sol Electric, Inc.
TSC—	Trans-Sil Corp.
USD—	United States Dynamics Corp.
USS—	U. S. Semiconductor Products, Inc.
VIC—	Vickers Inc.
WEC—	Western Electric Co.
WEST—	Westinghouse Electric Corp.

The following manufacturers have announced that they have begun supplying the indicated previously registered diodes and rectifiers.

BOGUE: 1N440 thru 1N445, 1N440B thru 1N445B, 1N530 thru 1N540, 1N560 thru 1N563, 1N599 thru 1N606, 1N599A thru 1N606A, 1N1095, 1N1096, 1N1100 thru 1N1105, 1N1487 thru 1N1492, 1N1556 thru 1N1560, 1N1692 thru 1N1695, 1N1763,1N1764, 1N2080 thru 1N2086

GENERAL INSTRUMENT: 1N316A thru 1N320A, 1N323A thru 1N327A, 1N548, 1N549, 1N659, 1N660, 1N661, 1N695, 1N708 thru 1N745, 1N761 thru 1N769,1N891, 1N892, 1N893, 1N1124 thru 1N1128, 1N1124R thru 1N1128R, 1N1341 thru 1N1348, 1N1486, 1N1518 thru 1N 1528, 1N1537 thru 1N1544, 1N1581 thru 1N 1598, 1N1612 thru 1N1616, 1N1764, 1N2080 thru 1N2086

HUGHES: 1N721 thru 1N724

KEMTRON: 1N253 thru 1N256, 1N332 thru 1N349, 1N440 thru 1N445, 1N440B thru 1N445B, 1N547, 1N550 thru 1N555,1N560 thru 1N563, 1N599 thru 1N614, 1N599A thru 1N614A, 1N1100 thru 1N1105, 1N1115 thru 1N1118

PACIFIC SEMICONDUCTORS: 1N761 thru 1N769

SYLVANIA: 1N770

NEW DIODES and RECTIFIERS

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(volts)	(°C)	MFR. (See code at start of charts)
1N316A	1	Si	50	50			.25	100	.60	70	50	150	BOG
1N317A	1	Si	100	100			.25	100	.60	100	100	150	BOG
1N318A	1	Si	200	200			.25	100	.60	120	200	150	BOG
1N319A	1	Si	350	350			.25	100	.60	240	350	150	BOG
1N320A	1	Si	500	500			.25	100	.60	250	500	150	BOG
1N321A	1	Si	850	850			.25	100	.60	210	850	125	BOG
1N322A	1	Si	1000	1000			.25	100	.60	210	1000	125	BOG
1N323A	1	Si	50	50			.40	100	.60	120	50	150	BOG
1N324A	1	Si	100	100			.40	100	.60	120	100	150	BOG
1N325A	1	Si	200	200			.40	100	.60	120	200	150	BOG
1N326A	1	Si	350	350			.40	100	.60	240	350	150	BOG
1N327A	1	Si	500	500			.40	100	.60	250	500	150	BOG
1N328A	1	Si	850	850			.40	100	.60	210	850	125	BOG
1N329A	1	Si	1000	1000			.40	100	.60	210	1000	125	BOG
1N359A	1	Si	50	50			.15	100	.60	75	50	150	BOG
1N360A	1	Si	100	100			.15	100	.60	100	100	150	BOG
1N361A	1	Si	200	200			.15	100	.60	120	200	150	BOG
1N362A	1	Si	350	350			.15	100	.60	240	350	150	BOG
1N363A	1	Si	500	500			.15	100	.60	250	500	150	BOG
1N364A	1	Si	850	850			.10	100	.60	210	850	125	BOG
1N365A	1	Si	1000	1000			.10	100	.60	210	1000	125	BOG
1N890	1	Si	70	60	20	1.0	.10	25		5.0	60	150	RHE
1N891	1	Si		50	50	1.0				25	50	100	GIC
1N892	1	Si		100	50	1.0				25	100	100	GIC
1N893	1	Si		200	50	1.0				25	200	100	GIC

NOTATIONS

Under Use

1. General Purpose
2. Power Rectifier
3. Magnetic Amplifier
Ø Insulated Base
5. Controlled Rectifier
6. Dual Rectifier
△ Direct Tube Replacement

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

☒ Dynamic

Under Mfr.

6. Available in stack form from that manufacturer

Following any temperature reading these symbols apply

A — Ambient
C — Case
J — Junction
S — Storage
△ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test condition for surge current and maximum peak recurrent current

Under E_f

☑ - at 125°C

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(E_f volts)	MAX. D.C. OUTPUT CURRENT[4] @ T (°C) (amps)	(°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_o @ T (uA)	(E_o volts)	(°C)	MFR. (See code at start of charts)
1N2103	2	Si	50		750	1.2	.75	25		300	50	25	USS
1N2104	2	Si	100		750	1.2	.75	25		300	100	25	USS
1N2105	2	Si	200		750	1.2	.75	25		300	200	25	USS
1N2106	2	Si	300		750	1.2	.75	25		300	300	25	USS
1N2107	2	Si	400		750	1.2	.75	25		300	400	25	USS
1N2108	2	Si	500		750	1.2	.75	25		300	500	25	USS
1N2109	2	Si	50		750	1.2	2.0	25		300	50	25	USS
1N2110	2	Si	100		750	1.2	2.0	25		300	100	25	USS
1N2111	2	Si	200		750	1.2	2.0	25		300	200	25	USS
1N2112	2	Si	300		750	1.2	2.0	25		300	300	25	USS
1N2113	2	Si	400		750	1.2	2.0	25		300	400	25	USS
1N2114	2	Si	500		750	1.2	2.0	25		300	500	25	USS
1N2512	2	Si	100	100	1000	1.1	4.0	25		2.0	100	25	RAY
1N2512R	2	Si	100	100	1000	1.1	4.0	25		2.0	100	25	RAY
1N2513	2	Si	200	200	1000	1.1	4.0	25		2.0	200	25	RAY
1N2513R	2	Si	200	200	1000	1.1	4.0	25		2.0	200	25	RAY
1N2514	2	Si	300	300	1000	1.1	4.0	25		2.0	300	25	RAY
1N2514R	2	Si	300	300	1000	1.1	4.0	25		2.0	300	25	RAY
1N2515	2	Si	400	400	1000	1.1	4.0	25		2.0	400	25	RAY
1N2515R	2	Si	400	400	1000	1.1	4.0	25		2.0	400	25	RAY
1N2516	2	Si	500	500	1000	1.1	4.0	25		2.0	500	25	RAY
1N2516R	2	Si	500	500	1000	1.1	4.0	25		2.0	500	25	RAY
1N2517	2	Si	600	600	1000	1.1	4.0	25		2.0	600	25	RAY
1N2517R	2	Si	600	600	1000	1.1	4.0	25		2.0	600	25	RAY
1N2518	2	Si	100	100	1000	1.1	4.0	25		2.0	100	25	RAY
1N2519	2	Si	200	200	1000	1.1	4.0	25		2.0	200	25	RAY
1N2520	2	Si	300	300	1000	1.1	4.0	25		2.0	300	25	RAY
1N2521	2	Si	400	400	1000	1.1	4.0	25		2.0	400	25	RAY
1N2522	2	Si	500	500	1000	1.1	4.0	25		2.0	500	25	RAY
1N2523	2	Si	600	600	1000	1.1	4.0	25		2.0	600	25	RAY
1N2524	2	Si		50			2.5	150	1.2	500	50	150	BRA
1N2525	2	Si		100			2.5	150	1.2	500	100	150	BRA
1N2526	2	Si		200			2.5	150	1.2	500	200	150	BRA
1N2527	2	Si		300			2.5	150	1.2	500	300	150	BRA
1N2528	2	Si		400			2.5	150	1.2	500	400	150	BRA
1N2529	2	Si		500			2.5	150	1.2	500	500	150	BRA
1N2530	2	Si		600			2.5	150	1.2	500	600	150	BRA
1N2531	2	Si		700			2.5	150	1.2	500	700	150	BRA
1N2532	2	Si		800			2.5	150	1.2	500	800	150	BRA
1N2533	2	Si		900			2.5	150	1.2	500	900	150	BRA
1N2534	2	Si		1000			2.5	150	1.2	500	1000	150	BRA
1N2535	2	Si		50			2.5	150	1.0	100	50	150	BRA
1N2536	2	Si		100			2.5	150	1.0	100	100	150	BRA
1N2537	2	Si		200			2.5	150	1.0	100	200	150	BRA
1N2538	2	Si		300			2.5	150	1.0	100	300	150	BRA
1N2539	2	Si		400			2.5	150	1.0	100	400	150	BRA
1N2540	2	Si		500			2.5	150	1.0	100	500	150	BRA
1N2541	2	Si		600			2.5	150	1.0	100	600	150	BRA
1N2542	2	Si		700			2.5	150	1.0	100	700	150	BRA
1N2543	2	Si		800			2.5	150	1.0	100	800	150	BRA
1N2544	2	Si		900			2.5	150	1.0	100	900	150	BRA
1N2545	2	Si		1000			2.5	150	1.0	100	1000	150	BRA
1N2546	2	Si		50			2.5	150	1.5	1000	50	150	BRA
1N2547	2	Si		100			2.5	150	1.5	1000	100	150	BRA
1N2548	2	Si		200			2.5	150	1.5	1000	200	150	BRA
1N2549	2	Si		300			2.5	150	1.5	1000	300	150	BRA
1N2550	2	Si		400			2.5	150	1.5	1000	400	150	BRA
1N2551	2	Si		500			2.5	150	1.5	1000	500	150	BRA
1N2552	2	Si		600			2.5	150	1.5	1000	600	150	BRA
1N2553	2	Si		700			2.5	150	1.5	1000	700	150	BRA
1N2554	2	Si		800			2.5	150	1.5	1000	800	150	BRA
1N2555	2	Si		900			2.5	150	1.5	1000	900	150	BRA
1N2556	2	Si		1000			2.5	150	1.5	1000	1000	150	BRA
1N2557	2	Si		700			6.0	150	1.2	500	700	150	BRA
1N2558	2	Si		800			6.0	150	1.2	500	800	150	BRA
1N2559	2	Si		900			6.0	150	1.2	500	900	150	BRA
1N2560	2	Si		1000			6.0	150	1.2	500	1000	150	BRA
1N2561	2	Si		700			6.0	150	1.0	100	700	150	BRA
1N2562	2	Si		800			6.0	150	1.0	100	800	150	BRA
1N2563	2	Si		900			6.0	150	1.0	100	900	150	BRA

TYPE NO.	USE (See Code Below)	MAT	PIV (volts)	MAX. CONT. WORK. VOLT. (volts)	Min. Forward Current @ 25°C I_f @ E_f (mA)	(volts)	MAX. D.C. OUTPUT CURRENT[4] (amps)	@ T (°C)	MAX. FULL LOAD VOLT. DROP[4] (volts)	Max. Rev. Current I_b @ E_b @ T (uA)	(volts)	(°C)	MFR. (See code at start of charts)
1N2564	2	Si		1000			6.0	150	1.0	100	1000	150	BRA
1N2572	2	Si		700			6.0	150	1.5	1000	700	150	BRA
1N2573	2	Si		800			6.0	150	1.5	1000	800	150	BRA
1N2574	2	Si		900			6.0	150	1.5	1000	900	150	BRA
1N2575	2	Si		1000			6.0	150	1.5	1000	1000	150	BRA
1N2583	2	Si		700			12	150	1.2	1000	700	150	BRA
1N2584	2	Si		800			12	150	1.2	1000	800	150	BRA
1N2585	2	Si		900			12	150	1.2	1000	900	150	BRA
1N2586	2	Si		1000			12	150	1.2	1000	1000	150	BRA
1N2594	2	Si		700			12	150	1.0	200	700	150	BRA
1N2595	2	Si		800			12	150	1.0	200	800	150	BRA
1N2596	2	Si		900			12	150	1.0	200	900	150	BRA
1N2597	2	Si		1000			12	150	1.0	200	1000	150	BRA
1N2605	2	Si		700			12	150	1.5	2000	700	150	BRA
1N2606	2	Si		800			12	150	1.5	2000	800	150	BRA
1N2607	2	Si		900			12	150	1.5	2000	900	150	BRA
1N2608	2	Si		1000			12	150	1.5	2000	1000	150	BRA
1N2630	2	Si	1500				.085	75A	2.25	350(4)			INRC
1N2631	2	Si	1600				.60	75A	3.0	350(4)			INRC
1N2632	2	Si	2800				.20	75A	6.0	350(4)			INRC
1N2633	2	Si	1600				.60	75A	3.0	350(4)			INRC
1N2634	2	Si	1600				.60	75A	3.0	350(4)			INRC
1N2635	2	Si	1500				.085	75A	2.25	350(4)			INRC
1N2636	2	Si	1500				.085	75A	2.25	350(4)			INRC
1N2637	2	Si	6400				.25	75A	12	350(4)			INRC
1N2772	2	Si		700			.50	150	1.8	100	700	150	BRA
1N2773	2	Si		800			.50	150	1.8	100	800	150	BRA
1N2774	2	Si		900			.50	150	1.8	100	900	150	BRA
1N2775	2	Si		1000			.50	150	1.8	100	1000	150	BRA
1N2776	2	Si		1100			.50	150	1.8	100	1100	150	BRA
1N2777	2	Si		1200			.50	150	1.8	100	1200	150	BRA
1N2778	2	Si		1300			.50	150	1.8	100	1300	150	BRA
1N2779	2	Si		1400			.50	150	1.8	100	1400	150	BRA
1N2780	2	Si		1500			.50	150	1.8	100	1500	150	BRA
1N2781	2	Si		1600			.50	150	1.8	100	1600	150	BRA
1SJ60A	1	Si	600	600			.10	100	.60	210	600	125	BOG
2E4	1	Si	400				.30	70A	.60	500(4)			INRC
2SJ60A	1	Si	600	600			.25	125	.60	210	600	125	BOG
3B30S	4	Si	30		2000	2.5	1.0	100C		10	30	25	SSP
3B60S	4	Si	60		2000	2.5	1.0	100C		10	60	25	SSP
3B100S	4	Si	100		2000	2.5	1.0	100C		10	100	25	SSP
3B150S	4	Si	150		2000	2.5	1.0	100C		10	150	25	SSP
3B200S	4	Si	200		2000	2.5	1.0	100C		10	200	25	SSP
4SJ60A	1	Si	600	600			.40	100	.60	210	600	125	BOG
5E4	1	Si	400				.50	70A	.60	500(4)			INRC
2105	1	Si	50	35	25A	1.5	13A	150C	.50	5000	50	150C	SYN
2110	1	Si	100	70	25A	1.5	13A	150C	.50	5000	100	150C	SYN
2115	1	Si	150	105	25A	1.5	13A	150C	.50	5000	150	150C	SYN
2120	1	Si	200	140	25A	1.5	13A	150C	.50	5000	200	150C	SYN
2125	1	Si	250	175	25A	1.5	13A	150C	.50	5000	250	150C	SYN
2130	1	Si	300	210	25A	1.5	13A	150C	.50	5000	300	150C	SYN
2135	1	Si	350	245	25A	1.5	13A	150C	.50	5000	350	150C	SYN
2140	1	Si	400	280	25A	1.5	13A	150C	.50	5000	400	150C	SYN
3305	1	Si	50	35	50A	1.3	37.5	150C	.50	5000	50	150C	SYN
3310	1	Si	100	70	50A	1.3	37.5	150C	.50	5000	100	150C	SYN
3315	1	Si	150	105	50A	1.3	37.5	150C	.50	5000	150	150C	SYN
3320	1	Si	200	140	50A	1.3	37.5	150C	.50	5000	200	150C	SYN
3325	1	Si	250	175	50A	1.3	37.5	150C	.50	5000	250	150C	SYN
3330	1	Si	300	210	50A	1.3	37.5	150C	.50	5000	300	150C	SYN
3335	1	Si	350	245	50A	1.3	37.5	150C	.50	5000	350	150C	SYN
3340	1	Si	400	280	50A	1.3	37.5	150C	.50	5000	400	150C	SYN
BR100	2	Si		700			.50	150	1.8	100	700	150	BRA
BR200	2	Si		800			.50	150	1.8	100	800	150	BRA
BR300	2	Si		900			.50	150	1.8	100	900	150	BRA
BR400	2	Si		1000			.50	150	1.8	100	1000	150	BRA

NOTATIONS

Under Use

1. General Purpose
2. Power Rectifier
3. Magnetic Amplifier
Ø Insulated Base
5. Controlled Rectifier
6. Dual Rectifier
△ Direct Tube Replacement

Other

4. For half wave resistive load average over 1 cycle

Under Reverse Current

☒ Dynamic

Under Mfr.

6. Available in stock form from that manufacturer

Following any temperature reading these symbols apply

A — Ambient
C — Case
J — Junction
S — Storage
△ — Inlet Temperature of Coolant

Type No.

† — Revised Data

Manufacturers should be contacted for value and test condition for surge current and maximum peak recurrent current

Under E_f

☒ - at 125°C

New Literature

Available from the Semiconductor Products Division of Bendix Aviation Corp., is a data sheet on their 2N1176,A,B "Yeoman" transistor. Sheet lists absolute maximum ratings, lead temperature, thermal resistance, small signal parameters, electrical test data, and other data. Illustrates mechanical characteristics of this transistor.

Circle 150 on Reader Service Card

Schweber Electronics announces an article about relays, "How Wet Is A Dry Circuit?" by their component specialist, Sam Kass. Brochure explains what a relay is made of (including an illustration of a relay), how to pick a winning relay, and Definitions of Relay Terms.

Circle 151 on Reader Service Card

A new 112-page catalog containing specifications for over 300 exclusive products used in the physical sciences has been issued by The Ealing Corp., a Baird-Atomic Affiliate. Items described range from Optical Benches and Cathetometers to Galvanometers and Electron Impact Tubes. Through a plan of special supplements to users, the Ealing Catalog will be kept current on a quarterly basis.

Circle 153 on Reader Service Card

A new booklet, "Medium and High Speed Switching Transistors," has been made available by Sylvania. The 24-page booklet lists maximum ratings and electrical characteristics for all PNP and NPN medium and high speed types in Sylvania's switching transistor line. It also contains nine transistor switching time measurement circuits, diagrams illustrating mechanical specifications and connections, and a section on transistor switching time requirements.

Circle 152 on Reader Service Card

A new 8-page catalog of diodes and capacitors is announced by J. C. Worth, Jr., sales vice president of U. S. Semiconductor Products. First printed in August for small quantity distribution at WESCON and revised in September, U. S. Semcor's new Catalog No. U.S.S.-8-59 gives brief dsecriptions, 1N numbers, and basic specifications of the complete semiconductor and tantalum capacitor line. Firms already in possession of the blue "Short Form Catalog" announced in June will find many additions and changes in this new green catalog, which follows the same general format with addition of pages.

Circle 160 on Reader Service Card

Finding the right flux for every soldering problem is made easier through the use of a new, technical data sheet just published by Alpha Metals, Inc. This "Alpha Flux-Finder Guide," as it is called, offers technical bulletins which deal in depth with such specific problems as selecting the right flux to prevent re-oxidation of base metals, reducing oxides in solder baths and providing high-speed fluxing for printed circuit dip soldering. Included is a special Solder Selector Chart.

Circle 154 on Reader Service Card

Thermo-Kanthal, a new composition of base metal thermocouple wire, offers significantly longer life and improved stability over commonly used thermocouple materials because of its greatly increased resistance to oxidation. Complete technical data on new Thermo-Kanthal alloys, as well as data for Thermo-Kanthal extension lead wires, is available in a four-page folder just released by The Kanthal Corporation.

Circle 155 on Reader Service Card

New two-page bulletin describes complete line of Mid-eastern Electronics transistorized power supplies featuring more than 60 off-the-shelf models including dual output types. New features of design are plug-in amplifiers, bias supplies and relay units with protective circuitry. Plug-ins are common to all 60 models. Complete specifications and prices are included.

Circle 156 on Reader Service Card

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Models for all jobs requiring very thin slicing of semi-conductor and other difficult-to-cut materials.

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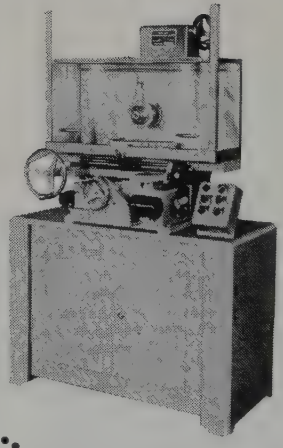

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EFFICIENT. Visual undistorted pattern allows immediate adjustment. Requires no interpretation or correlation with charts and data.

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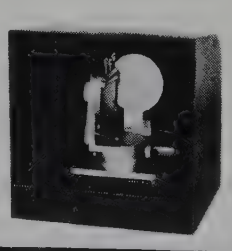

MICROMECH MANUFACTURING CORP.

A Division of Sanford Manufacturing Corp.

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Circle No. 24 on Reader Service Card

National Ultrasonic Corporation announces the availability of a 12-page Ultrasonic Cleaning Primer for use as a guide by potential users of ultrasonic cleaning equipment. The Primer is designed to provide a clearer understanding of what ultrasonic cleaning is, how it works, areas in which it can be employed and various solvents and detergents available for use with this kind of equipment.

Circle 157 on Reader Service Card

One of the most unusual publications ever to be produced by a private manufacturer, has been made available for distribution to qualified personnel by Ohmite Manufacturing Company. Designated formally as a "catalog" of military electronic components, it is simultaneously an invaluable handbook on U. S. military specifications covering those components which Ohmite manufactures. Request catalog 50.

Circle 158 on Reader Service Card

Optical Silicon for use in infrared surveillance and detection devices is produced by Dow Corning Corporation in large crystalline ingots having less than two parts impurity per 100 million. From these ingots, individual blanks for lenses, optical windows and hollow domes to 7" diameter are manufactured. Prisms, flats and specially shaped optical blanks are also produced to specifications for optical grinding. 4-page brochure illustrates silicon ingots, blanks in various shapes and sizes and blanks finished to specifications. Properties are given and illustrated by curves.

Circle 170 on Reader Service Card

Linde Company, Division of Union Carbide Corporation, now has available single crystal Yttrium Iron Garnet and has just published a new Industrial Crystals Bulletin discussing the growth of this new material. YIG is of great interest in solid state amplifiers. The Bulletin was prepared by R. G. Rudness, of Linde's Speedway Laboratories and R. W. Kebler, now of the General Motors Technical Center, Research Laboratories, in cooperation with the Lincoln Laboratory of M.I.T. It is entitled "Growth of Single Crystals of Incongruently Melting Yttrium Iron Garnet by the Flame Fusion Process."

Circle 159 on Reader Service Card

LEL catalog #96 provides 22 pages of information on microwave receiver front ends, R.F., I.F., and TWT amplifiers, telemetering preamplifiers, noise test sets, and beacons. Information is included on electrical characteristics, mechanical construction, general applications. A number of new additions are described, including an X-Band low noise microwave mixer-amplifier assembly, a hybrid transistorized amplifier with a ceramic triode input, and a crash locator beacon.

Circle 161 on Reader Service Card

Physical And Engineering Properties Of Materials For Nuclear Fuel Elements, is a compendium of physical and engineering data about elements, alloys, compounds and other materials of particular interest to those engaged in the design, fabrication and use of nuclear fuel and control elements. It serves admirably its intended purpose of supplying information not yet widely available in conventional reference sources. Available at nominal cost from Sylvania-Corning Nuclear Corp.

Circle 162 on Reader Service Card

An eight-page paper on industrial Gold plating, by E. C. Rinker, Technical Director, Precious Metals Division, Sel-Rex Corporation, is available. Originally presented before the 40th Annual American Electroplaters' Society, the paper treats, in great detail, such topics as bath composition, equipment and operating conditions, and comparative metallurgical characteristics of 24K Gold Plate on various base metals. Profusely illustrated with photomicrographs of gold plated surfaces and cross sections, the paper also includes a series of graphs and tables indicating rates of deposition at various current densities and under different operating conditions.

Circle 163 on Reader Service Card

Valor Instruments, Inc. Bulletin DL1159 describes a standard line of miniature lumped constant delay lines. Data is provided on the electrical specifications, packaging and the unique construction techniques which enable a high degree of miniaturization. Design factors that should be considered when establishing specifications for special delay lines are also explained.

Circle 164 on Reader Service Card

A new, colorful chart is available from Emerson & Cuming, Inc., giving properties of Dielectric Materials at Microwave Frequencies over a wide range of dielectric constant and dissipation factor.

Circle 165 on Reader Service Card

(continued on page 63)

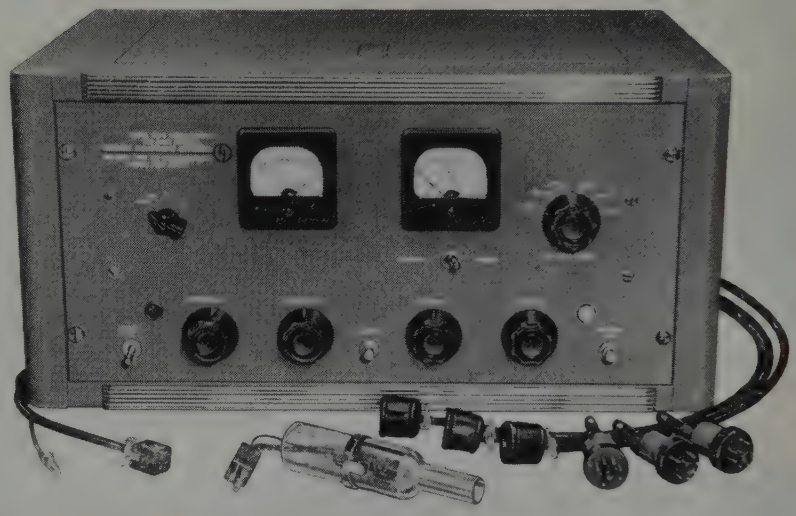
Kinney®

New Vacuum Gage Measures Pressures in Two Ranges···

✓ 3 mm to 1μ Hg

✓ 1μ to 0.1 mμ Hg

GICT—Cabinet Model



The KINNEY GICT Ionization-Thermocouple Gage covers the range from 3000 microns to below 10^{-7} mm Hg...a two meter instrument providing simultaneous Ionization Gage and Thermocouple Gage readings. Available in portable cabinet and panel mounted models. The standard unit is supplied with one position Compensated Thermocouple Gage and it can be supplied in modified form with 2, 3, 4, 5 or 6 position Gage at extra cost.

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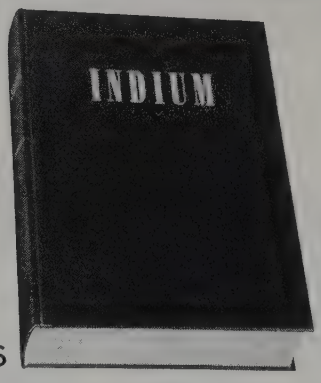

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Circle No. 27 on Reader Service Card

Industry News

CONFERENCE CALENDAR

The following January 1960 Meetings Are Scheduled:

Jan 11-13 6th National Symposium on Reliability & Quality Control. Statler-Hilton Hotel, Washington, D. C. Sponsored by PGRQC, AIEE, ASQC, EIA. For Information: C. M. Ryerson, RCA, Camden, N. J.

Jan 25-28 13th Annual Symposium on Modern Methods of Analytical Chemistry. Louisiana State University, Baton Rouge, La.

Jan 27-30 American Physical Society, New York City.

DEADLINES FOR PAPERS AND/OR ABSTRACTS

1960 General Electronics Symposium—Spring meeting of the Electrochemical Society. Papers are being solicited on unique electronic instrumentation, oxide cathodes, micro-modules, thermoelectric generators and other related subjects. Authors are requested to submit triplicate copies of title of paper and abstract of 75 words or less before January 1, 1960. A longer abstract, not exceeding 1000 words, for printing in an enlarged abstract booklet, is required not later than January 15, 1960. Amount of time for presentation of papers should be indicated, as well as name of person who will present the paper. All inquiries should be sent to Alfred E. Martin, Polarad Electronics Corp., 43-20 Thirty-Fourth Street, Long Island City 1, N. Y.

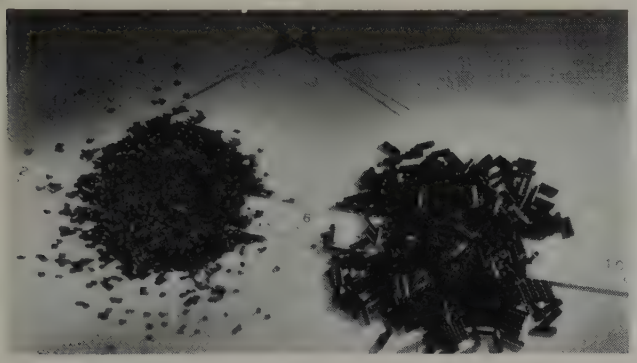
10th Annual International Symposia of The Microwave Research Institute of the Polytechnic Institute of Brooklyn to be held in New York City April 19-21, 1960. Papers given will include these topics: Physical Realizability of Active Networks, Representation and Synthesis of Active Networks, Synthesis of Feedback Networks, Time Varying Systems, Applications of Active Network Theory to Electron Devices, Applications of Active Network Theory to Feedback Systems. Deadline for papers and/or 100 word abstracts is January 15, 1960. Correspondence should be addressed to Prof. Herbert J. Carlin, Microwave Research Institute, 55 Johnson Street, Brooklyn 1, N. Y.

RESEARCH & DEVELOPMENT

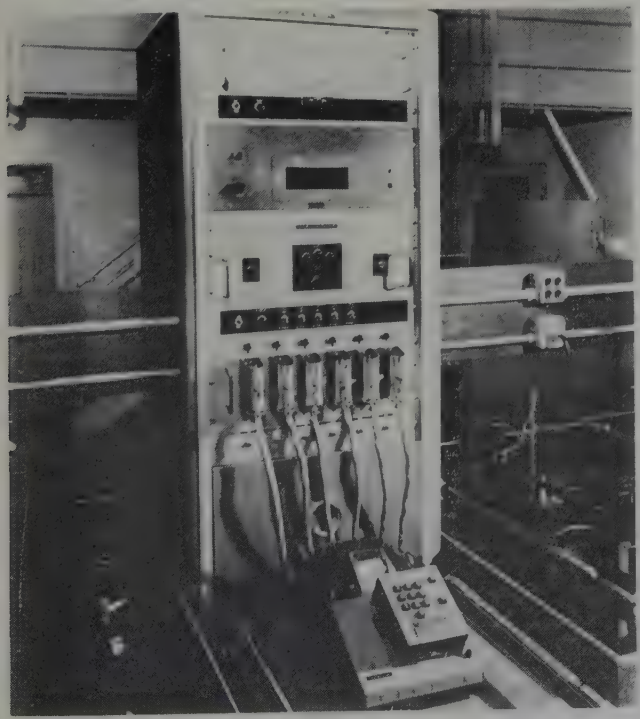
The National Bureau of Standards has developed a special-purpose computer for the Weather Bureau to analyze data received from a ceilometer, or cloud height indicator. On command, this small-scale data processor will tell an operator not only what the cloud height is at present, but what the highest, lowest, or predominant cloud height was at any time in the last 10 min, or how often clouds occurred below some critical level during this same period. The instrument was developed by J. A. Cunningham and Paul Meissner of the Bureau's data processing systems laboratory as part of a program to assist and advise the Weather Bureau in applying com-

puter techniques to automatic weather data analysis. Except for the output switches and magnetic drum, the equipment is entirely transistorized and was made almost exclusively digital in operation to assure a high degree of reliability.

A black glass that is impervious to light has been developed by Corning Glass Works for enclosure of silicon semiconductor devices. The glass is being offered in the form of beads and cases for sealing to standard .017 Dumet lead wires. Opaqueness is a fundamental characteristic of this glass. It filters out virtually all wavelengths of the ultraviolet, visible and near infrared spectrum. Silicon semiconductor crystals are sensitive to such radiation. The black glass permits economies in mass production of the electronic devices, according to Corning. It eliminates the need to paint the devices and solves the costly problem of surface rub-off or scratching. The company said the glass, designated Code 9361, has physical properties equivalent to the standard clear glass now used by diode manufacturers.



New Automatic Test Console developed by Hoffman Electronic Corporation's Semiconductor Division speeds up operating run-in tests on Zener reference units by 700 per cent. Console supplies a constant current from its power circuit to operate 300 Zener diodes undergoing oil bath tests. Console's digital voltmeter measures voltage of each Zener unit and feeds results into an automatic data-taking device. Data then is transmitted into digital readout machine which records the information



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500 watts output

Transducerized Tank NT-5001
Capacity: 10 gallons
Dimensions: 20" L x 11½" W x 10" D

Generator features tank selector and load selector switches on front panel to operate one or two NT-5001 tanks alternately. Other combinations of tanks and submersible transducers available from stock; larger tanks available on special order.

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Here's a new Narda SonBlaster ultrasonic cleaner with tremendous cavitation activity and generating capacity! Featuring full 500 watts output, this SonBlaster is available with a fully transducerized giant 10-gallon capacity tank. In addition, it will operate from six to 10 Model NT-605 high energy submersible transducers, at any one time, in any arrangement in any shape tank you need up to 70-gallon volume.

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Whether you're interested in mass-production cleaning or degreasing of mechanical, electronic, optical, or horological parts or assemblies ... rapid, quantity cleaning of "hot-lab" apparatus, medical instruments, ceramic materials, electrical components or optical and technical glassware ... or in speeding up metal finishing and chemical processing of all types—you'll find this new SonBlaster will do your work faster, better and cheaper. Write for more details now, and we'll include a free questionnaire to help determine the precise model you need. Address: Dept. SP-20.

Consult with Narda for all your ultrasonic requirements. The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers which can be adapted to any size or shape tank you may now be using. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available for immediate delivery from stock—and at the lowest price in the industry ($175 up)!

For custom-designed cleaning systems, write to our Industrial Process Division; for information on Chemical processing applications, write to our Chemical and Physical Process Division; both at the address below.

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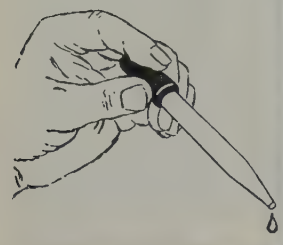
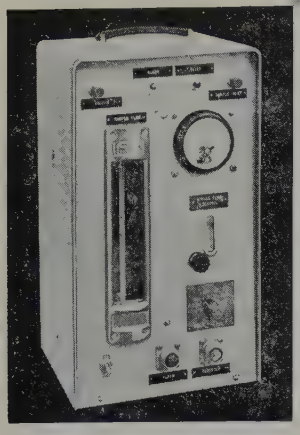


Measures water content better than 1 part per 1,000,000!



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MEECO Instruments

Circle No. 29 on Reader Service Card

on each diode on adding machine tape. Each diode's voltage, which is read and recorded by the console at three different environmental temperatures, is compared for "drift." Diodes with excessive drift are rejected.

The discovery of a method for pressing rods of commercially available powered boron has led in turn to successful floating zone melting of that extremely high-melting element. The technique will provide larger crystals for basic research studies of this semiconductor than have been available before. The new method was developed by Dr. E. S. Greiner of Bell Telephone Laboratories. Crystals as large as 0.1 inch have been obtained, many of which were twinned.

SPECIAL SERVICES

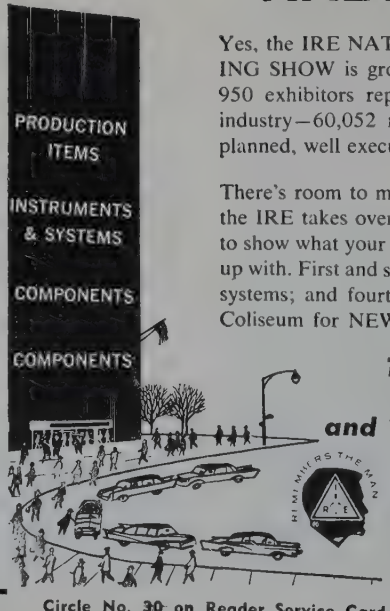
A circuit design "task force" has been organized to provide on-the-spot counseling service for Hughes semiconductor customers throughout the United States. Engineers experienced in semiconductor techniques and circuit system relationships will be available without charge to solve customers' design problems for small and complex systems. They will be located in key U. S. cities to solve circuitry problems at customers' plants. Heading the new service is Bernard Diener, who has twenty years' experience in electronic engineering and design, eight of them at Hughes. Headquartered in Newport Beach, Calif., Mr. Diener will visit customers' facilities to discuss their problems on the spot. Other engineers within his group are also available under the new marketing set-up. Further information may be obtained from Circuit Counseling Department, Hughes Semiconductor Division, Newport Beach, California.

UPPER STRATA STRATEGY!

Friend of ours who always attends the sessions in the lecture halls, *starts* on the Fourth Floor with Production Items . . . and works his way down to Components on the First Floor. Says his feet tell him it's easier to come down than to go up! And he never misses a trick this way. Sounds like good engineering logic. Why don't you join him this year . . . and see if it doesn't work for you!

Will Copp

Show Manager



1959 IRE SHOW REGISTRATION: 60,052

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Yes, the IRE NATIONAL CONVENTION and RADIO ENGINEERING SHOW is growing bigger every year, and drawing more people—950 exhibitors representing 80% of the productive capacity of your industry—60,052 registrants last year! Yet, it's one of the most well planned, well executed gatherings you'll ever see!

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The IRE NATIONAL CONVENTION
Waldorf-Astoria Hotel
and The RADIO ENGINEERING SHOW
Coliseum, New York City

MARCH 21, 22, 23, 24

The Institute of Radio Engineers
1 East 79th St., New York 21, N. Y.

Circle No. 30 on Reader Service Card

New Literature

(*from page 59*)

Scherr-Tumico announces their new 1959-60 Guide & Catalog of Precision Measuring Tools and Instruments consisting of 96 fully illustrated pages is now available. This catalog contains complete detailed information on Scherr Measuring Tools and Toolroom Specialties, such as a complete line of Micrometers, Vernier Depth Gages, Snap Gages, Protractors, Dial Indicators, Ultra-Chex Gage Block Sets, Height Gages, Speed Indicators, Hand Tachometers, Dynamometers, Radius Dressers, Optical Flats, Surface Plates, Magni-Ray, Illuminated Magnifiers, etc.

Circle 166 on Reader Service Card

A new booklet that describes and illustrates the company's plastic moldings is available from Continental-Diamond Fibre Corp. Titled "CDF Moldings," it fully discusses the company's compression, transfer and injection molding processes and lists the materials and sizes of parts available by each process. This 2-color, 12-page booklet also presents complete descriptions and a table of properties for nine CDF molding materials.

Circle 167 on Reader Service Card

A complete informative reference on the composition, qualities and applications of carbon-graphite is offered by The Ohio Carbon Company in the form of an 8-page brochure. Available on request to designers, engineers, purchasing and management personnel interested in the mechanical, thermal and chemical applications of this versatile material, manufactured and machined by Ohio Carbon under the name of "Karak."

Circle 168 on Reader Service Card

BACK ISSUES AVAILABLE

75¢ each

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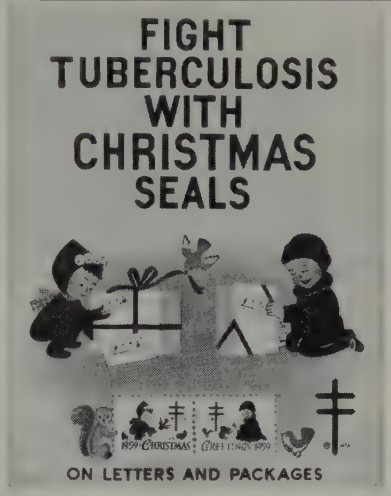

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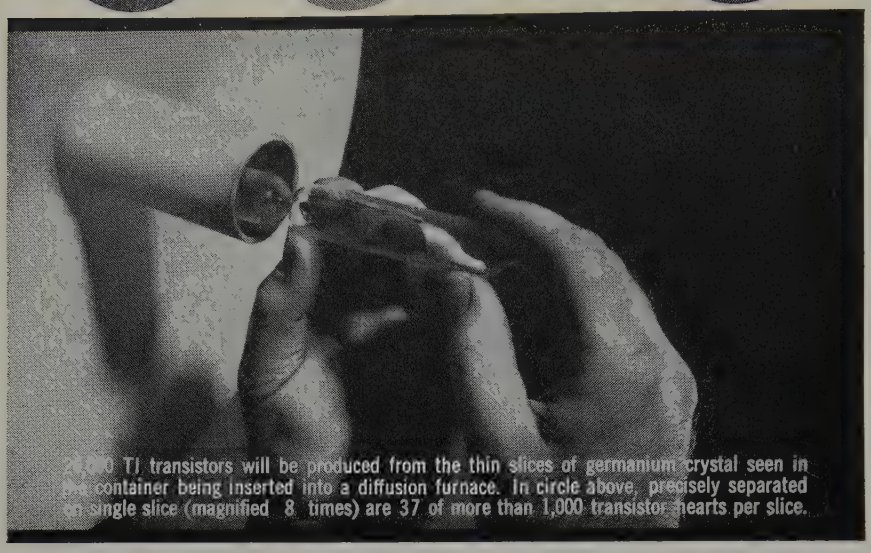
CAREER OPPORTUNITIES AT TI



2,000 TI transistors will be produced from the thin slices of germanium crystal seen in the container being inserted into a diffusion furnace. In circle above, precisely separated on single slice (magnified 8 times) are 37 of more than 1,000 transistor hearts per slice.

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For immediate Eastern appointment, contact
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Dept. 201-SC
1141 E. Jersey St.
Elizabeth, N. J.

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MARKET NEWS . . .

Sales

The United States Department of Commerce statistics show that the value in dollars of Japanese exports in transistors to the United States for the first six months of 1959 was $521,000 for 823,000 units as against only $7,000 for 11,000 units during the entire year of 1958.

The Electronic Industries Association has recently reported that factory sales of transistors during the month of August has set an all time record. Cumulative sales for the first eight months of this year, according the Association, has exceeded the total number of transistors sold during 1958. Total factory sales during 1958 amounted to 47,051,000 units valued at $112,730,000.

New Companies

Controls Company of America has formed a new subsidiary, Solid State Electronic Controls, Inc. Construction of a 10,000 square foot plant on approximately eight acres of land in Tempe, Arizona has been started and should be completed by the end of the year. The firm plans to grow crystals and manufacture such items as silicon solar converters and other semiconductor devices, including rectifiers and diodes. Particular emphasis will be placed on industrial and commercial controls and instrumentation applications.

National Semiconductor Corporation, Danbury, Conn., has started actual production of p-n-p silicon alloy "small signal" type transistor. The firm plans early production of other types of transistors and semiconductor diodes.

Suppliers

Accurate Specialties Co., Inc., Woodside, N.Y., a producer of high purity ultra-precise alloy preforms and stampings for transistor and diode manufacturers, has acquired 80% of the common stock of Duramic Products, Inc., N.Y. This move will assist Duramic in their planned expansion to fill the demand of the semiconductor industry for their alloying and soldering tooling. Accurate Specialties has announced a net income of $66,269 for the year ending June 30, 1959 as against $5,955 last year.

Expansions

R.C.A. has recently broken ground for a new transistor and rectifier plant in Mountaintop, Pa. Their new plant is expected to be in production by mid-1960 when they will expand their silicon rectifier line from 13 to 50 more types.

Solid State Electronics Co., has moved to its new plant in Sepulveda, California. The company was formerly located in Van Nuys.

Fairchild Semiconductor Corporation, Mountain View, California, plans to expand its production facilities from its

present 68,000 square feet to 183,000 square feet. The company, having grown from 13 to nearly 700 employees in two years, now plans to employ 2,000 by the end of 1960. This will make Fairchild one of the largest producers of silicon transistors.

Minneapolis-Honeywell Regulator company is constructing a 40,000 square foot building in Riviera Beach, Fla. for advanced research and development in the field of semiconductor products. The plant will eventually employ 1000 persons and is expected to be ready for occupancy by early summer 1960. Some 40 scientists, engineers and technicians will be transferred from other locations of the company to Riviera Beach before the end of this year.

Tokyo Shibaura Electric Co., Ltd. (Toshiba) is expected to be able to double their production of transistors with the opening of the recent addition to their existing facilities near Tokyo. The new highly automated plant will be able to produce 2 million units per month with 500 employees, mostly women, as compared with the present plant, employing 1200 women and 300 men, which has the same capacity.

Mistral Co., Sermoneta, Italy, has opened a new plant for manufacturing entertainment-type transistors for the European and American markets. It is expected that the plant will produce 4½ million transistors by the end of 1960.

The Semiconductor Division of Ratheon Co., has added 29 new devices to its line of semiconductors.

Western Electric Co., has made plans to build a $2 million plant in Muhlenberg Township, Pa., for manufacturing transistors and other electronic equipment. Partial occupancy will be made of the new facilities by Spring 1960.

Ohio Semiconductors Inc., Columbus, Ohio, has acquired a third building for the production of its solid state devices and semiconductor materials. The new addition will add 23,000 square feet to its existing facilities.

Distributors

Silicon Transistor Corp., Carle Place, N.Y., has added four new industrial distributors for their line of silicon diodes and power transistors. These distributors are in Waterbury, Conn., Medford, Mass., Oakland and San-Jose, Calif.

General Instrument Corporation has established a West Coast Sales Engineering office in Los Angeles to handle all General Instrument divisions including their Semiconductor Division.

U. S. Transistor Corporation, Syosett, L.I., N.Y., has appointed twelve sales representatives throughout the country.

Semiconductor Distributor Specialists, Chicago, a newly formed electronic distributor specializing in semiconductors has been appointed distributor in the Mid-West for Fairchild Semiconductor Corporation in addition to handling Clevite Transistor Products.

Contracts

Consolidated Avionics Corporation, Westbury, N.Y., is supplying special dual-output, airborne transistorized power supplies under a $270,000 subcontract from Loral Electronics Corporation.

Prices

Radio Receptor Co., Inc., Brooklyn, N.Y., has eight new subminiature plastic-encapsulated, color coded, selenium diodes whose prices range from 15 to 35 cents in production quantities.

Philco Corporation has reduced prices on six types of transistors in 3 to 18 mc frequency range.

Texas Instruments Inc., has announced prices on its new multi-purpose silicon mesa transistor series. These units are available in quantities of 1 to 99 at $28.50 and 100 to 999 at $19.

The Semiconductor Division of Hoffman Electronics Corporation has introduced a line of silicon Zener regulators to sell for an unusually low price of less than $1 each in quantity lots.

Merck and Company Inc., Rahway, N.J., also reduced prices on its ultrapure silicon crystals from $1.89 a gram to $1.55 a gram depending upon the grade.

Sylvania Electric Products Inc., Towanda, Pa., has announced a new price schedule to manufacturers of semiconductor devices for the conversion of germanium scrap. The new schedule represents a price reduction of up to 25% and also includes charges for processing scrap containing less than 10% germanium.

Financial

Electronic Transistor Corporation, North Bergen, N.J., a prime and secondary source for transistors, diodes and rectifiers, has offered 85,000 additional shares of common stock at $3.00 a share. The offering is limited to residents of New Jersey.

Hoffman Electronics Corporation had $1,565,366 net earnings for the nine months ending September 30, in comparison with $1,248,963 earned in the similar period of last year.

Fairchild Camera and Instrument Corporation, Syosett, L.I., N.Y., has announced a profit of $1.16 per share, or $580,000 for the third quarter of 1959. This puts the company's profits for the first nine months of the year at $2.77 per share as against 19 cents per share for the same period last year. The company has also recently exercised its option to purchase all of the common stock of Fairchild Semiconductor Corporation.

General Instrument has reported a profit of $613,610 for the six months period ending August 31. This represents a 73% increase over the $354,477 earned during the same period in 1958. Semiconductor sales paced the gains and were up 115% over the first half in 1958. The backlog in semiconductors was almost triple that of the same period a year ago.

Daystrom, Incorporated had a net income of $802,000 or 88 cents a share for the six months period ending September 30 as compared with $369,000 or 41 cents per share for the like period in 1958.

Microwave Associates, Burlington, Mass., manufacturer of semiconductor diodes, semiconductor products, microwave radar, etc., has won the approval of the American Stock Exchange for original listing of 1,053,616 shares of $1 par value stock.

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Silicon Diodes

A new series of high-current, high speed silicon switching diodes has been announced by Sperry Semiconductor. Available in four voltages, the Series 1N690-1N693 diodes effect 0.8 μsec switching of ½-ampere pulses and meet other stringent requirements of high current pulse circuits for high speed computer switching, pulse clamping, gating, blocking and diode logic circuits. Designed for operation from −65°C to +150°C, these diodes also feature high forward conductance (400 ma at 1 volt) and low leakage (50 μa at 150°C).

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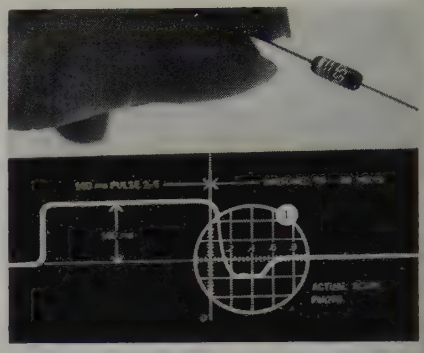

Subminiature Delay Line

A one usec delay line with a 0.2 usec rise time is available, from Valor Instruments, in a 0.4" x 1.5" metal case. The precision lumped constant unit, designated as 10C5-5/14, is suitable for printed circuit and transistor applications. Characteristic Impedance 1400 ohms; Attenuation 3%; Temperature Characteristic −0.03%/°C; Temperature Range −55°C to +105°C; Built to MIL Specifications; Molded in hermetically sealed brass tube with leads brought out through glass-to-metal end seals.

Circle 116 on Reader Service Card

Variable Transformers

Ohmite Manufacturing Company announces a supplementary line of cased variable transformers for portable use or for fixed-mounting. Cased models are stocked for immediate shipment in the conventional "overvoltage" types (where maximum output voltage exceeds input voltage). These models cover a range to 7.5 amperes rating. Ohmite also can supply, to order, cased "no-overvoltage" types (where maximum output voltage equals line input voltage.) The no-overvoltage types offer greater output for equal physical size, and cover a range up to 10 amperes. Request Bulletin 151.

Circle 126 on Reader Service Card

(Top Left) VT8E Fixed-Mounting in Conduit Line

(Top Right) VT8F Regular Portable

(Right) VT8G DeLuxe Portable

New Products

Zener Regulators

The new Hoffman Silicon Zener Regulator line consists of two types. The RS-6 has a reverse breakdown voltage of 6 volts plus or minus one volt and a maximum dynamic impedance of 15 ohms, while the RT-6 has 20 ohms of maximum dynamic impedance at the same reverse breakdown voltage. The voltage for both types is rated at 10 milliamps, DC. Dynamic impedance is measured at a current level of 10 milliamps with one milliamp superimposed.

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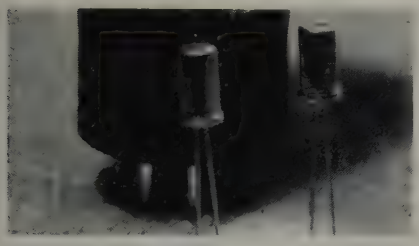

Micro Micro-Diode

A "micro-micro" diode, so small it looks to the naked eye like a flyspec on a wire, yet so rugged it can withstand space shocks of 20,000 times gravity, was recently announced by Pacific Semiconductors. It weighs 14.09 milligrams compared with 160 milligrams for a silicon diode considered standard. It also represents an unusual chemical bonding of the molecules of the silicon crystal with surface elements that serve as a protective coating.

Circle 107 on Reader Service Card

Transistor Tester

A programmable constant current source has been introduced by North Hills Electric Co. Designed especially for transistor and semiconductor measurements, the CS-111 constant current source has a range of 10 μa to 500 ma from 0 to 200 V.D.C. Current is set to five places by decade knobs arranged to provide a digital inline readout. Line and load regulation are better than 0.05% with stability assured by a chopper stabilized feedback system. The current may be programmed or modulated by a remote signal.

Circle 109 on Reader Service Card

Silicon Power Rectifier

Transitron Electronic Corporation announces the availability of the ceramic base silicon power rectifier in an $^{11}/_{16}$" configuration, with ratings up to 20 amps @ 150°C case temperature. Ceramic base rectifiers of compact design eliminate the need for insulating hardware and reverse polarity units. These stud-mounted silicon power rectifiers have an alumina ceramic disc mounted between the top hat assembly and the hex base, thereby electrically insulating the mounting base from the rectifying junction. Request TE-1351R.

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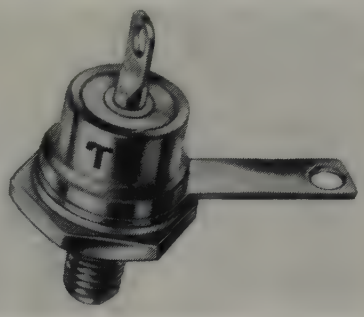

Multi-Purpose Transistors

Mass production of a new multi-purpose silicon mesa transistor series was announced by Texas Instruments Incorporated. The TI 2N696 and the TI 2N697, are equally suited for medium power and small-signal amplifier as well as switching applications. Both are capable of 2 watts dissipation at 25°C case temperature and are available with a collector-base voltage of 60v. Both have a guaranteed beta spread, 20 to 60 for the TI 2N696 and 40 to 120 for the TI 2N697, and a maximum saturation resistance of 10 ohms.

Circle 131 on Reader Service Card

Complementary Power Transistors

A line of complementary NPN-PNP power transistors in industrial packages (8 pairs) has been announced by CBS Electronics. They are mounted in TO-10 (male) and TO-13 (female) packages and are supplied with solder lugs or flying leads. They feature high voltages (up to 100 volts) and proven quality (exceeding MIL-T-19500A) for audio, control, voltage regulation, servo and computer applications. All types in the line have a maximum collector current of 3 amps, a minimum large-signal current gain of 30 (for a collector current of 0.5 ampere), and a maximum thermal resistance of 3° C/W.

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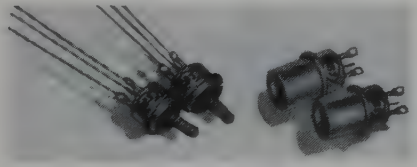

FAIRCHILD
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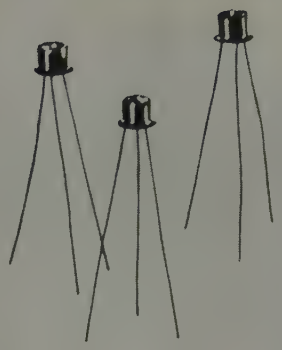

The following Fairchild transistors are available from stock for same day shipment in quantities up to

1000

pieces per type.

Standard NPN: 2N696, 2N697. High Voltage NPN: 2N699. High Beta NPN: 2N1420. Low Storage NPN: 2N1252, 2N1253. Standard PNP: 2N1131, 2N1132. Mesa: 2N706.

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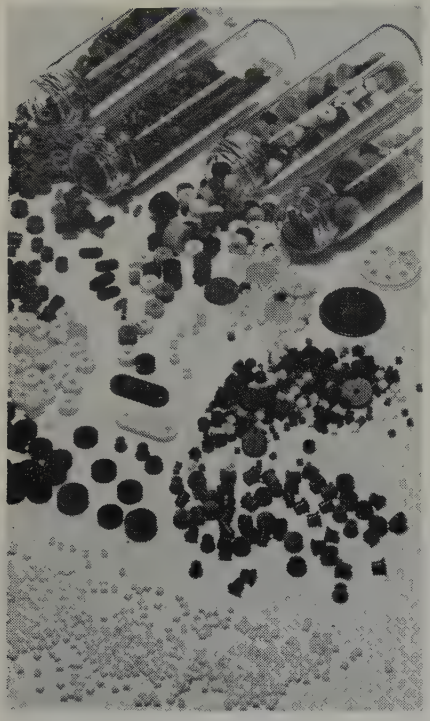

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Industrial Power Supplies

Hevi-Duty Electric Company, A Division of Basic Products Corporation, announces a complete range of AC and DC Industrial Power Supplies. These supplies are designed to regulate voltage, current, or power for industrial processes. These systems are engineered and manufactured to meet customer specifications. They are factory assembled and wired with all components in a single enclosure. Designed to handle input to 15 KV, single phase or three phase, 25-60 cycles; Output ratings to 100,000 amperes, single phase, two phase, three phase or direct current.

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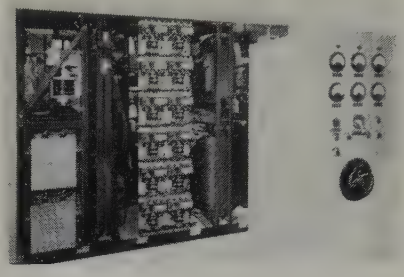

Vapor Pressure System

Utilizing vapor pressure system to control humidity with no wet bulb control wick to change or become contaminated, Blue M Electric Company's new Counter-Flow Controlled Humidity Cabinets have a wide range, from 35°F. to 185°F. Temperature range and relative humidity 40 to 98% with tolerances of ±2% R.H. Built-in mechanical refrigeration system permitted to run constantly (no stopping and starting) and coolant controlled through a directional solenoid valve permit longer life and closer control of wet bulb temperatures. Other features are shielded conditioning chamber, extended surface cooling coil and full inner glass door.

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Floating Zone Scanning Machine

Precise production of ultra-pure metals and semiconductor materials is possible with the Ther-Monic Model T-24 FZ Floating Zone machine introduced by Induction Heating Corporation. The new vertical floating zone scanner will process bars up to 1.250" in diameter and 24" in length. Scanning speed is continuously variable with an approximate range of 0-12" per hour. Return speed is continuously variable with a range of 40 to 800" per hour.

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Transistorized Amplifier

IF-83 is the latest addition to the LEL Series 80 transistorized I.F. Amplifiers. It is a hybrid unit which combines the low-noise properties of a tube input circuit with the low-power requirements and ruggedness of transistors. A type 7077 subminiature ceramic triode followed by 5 silicon tetrode transistors provides a unit capable of withstanding high shock and vibration. Noise figure is better than 2.5db.

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Power Supply Capacitors

New development in capacitor manufacture is the Sprague Electric Type 32D Compulytic Capacitor. Designed to meet 85°C operating conditions as standard, they are a giant step forward from the 65°C capacitors. In the large standard case size, 3" diam. x 4⅝" long, it is possible to obtain 85°C Compulytic Capacitors with a rating of 130,000μ F at 2½ volts or 630μF at 450 volts. Capacitor banks as large as 1 farad of capacitance have been constructed using this type. Request Bulletin 3441A.

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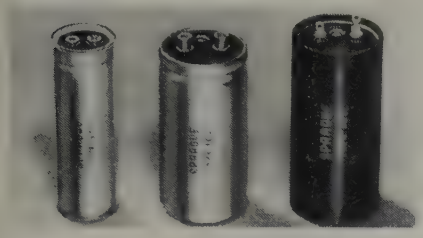

Mesa Computer Diodes

Five new silicon mesa computer diodes have been introduced by Microwave Associates. Maximum recovery time when switched from the forward bias with 10 milliamps current flowing, to reverse bias of −5 volts, is 4 millimicroseconds. These miniature, glass packaged diodes will satisfy the requirements of future computer circuitry for ultra-fast recovery time, higher breakdown voltages, and silicon mesa construction to meet operating temperature requirements.

Circle 113 on Reader Service Card

Indium Antimonide Photocell

A new and highly sensitive photoconductive cell has been announced by International Electronics Corp. Made of indium antimonide, the Mullard ORP10 has its sensitivity in the infra-red radiation range up to 7.5 microns at room temperature. The actual spectral response range is from the visible to 8.0u, the peak response being 6.0 to 6.5u. The sensitivity is measured with 2uW of radiation falling on the sensitive area and 50mA dc applied to the cell.

Circle 92 on Reader Service Card

Ultrasonic Cleaning Unit

National Ultrasonic Corporation announces the availability of a new unit for small part cleaning applications in which average energy levels are required. Model 100 features a one-gallon heavy-gauge polished stainless steel tank, deep drawn with rounded corners to facilitate the rinsing out of contaminants removed by ultrasonic energy. The tank is 9¼" long, 5" wide and 6" deep. 25% of the tank bottom is covered with driving elements and actual radiating surface is 12 square inches.

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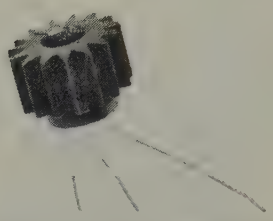

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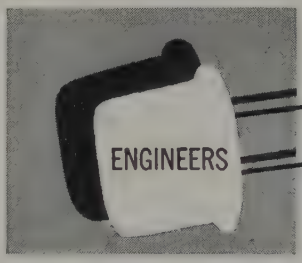

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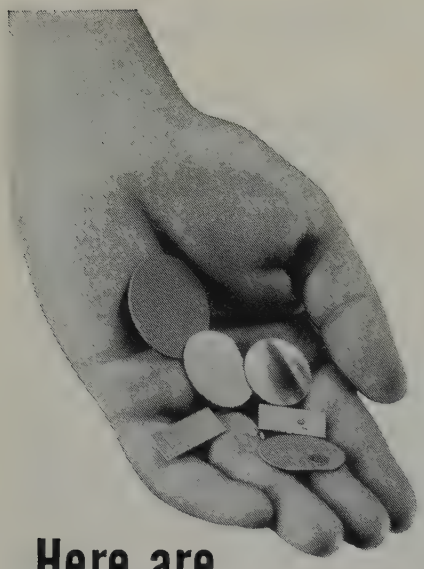

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Military-Type Transistor

2N1120, a high-current, high-power switching transistor, now in production by Bendix Aviation Corporation, has been designed to meet the specification MIL-T-19500/68 (SigC). Its maximum collector current rating of 10 Adc makes it particularly appropriate for high current switching applications, while a collector-emitter voltage rating of 70 Vdc suits it equally well to high voltage applications. It will readily dissipate 45 watts at a 25°C mounting base temperature.

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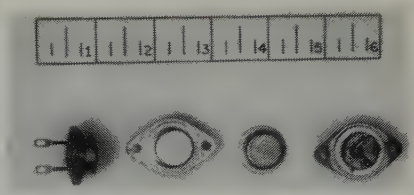

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Silicon Trigistor

The Silicon Trigistor is a "Circuit Equivalent" component with characteristics comparable to a flip-flop or bistable multivibrator. Developed by Solid State Products, Inc., it is a silicon PNPN device with the property of triggered turn-off as well as triggered turn on control at its base. The 3C series Trigistors have collector voltage ratings to 60V. Maximum operating temperature is 125°C. Turn on time of 0.4μ seconds is typical, with circuit repetition rates to 200 KC. They are in the JEDEC Standard TO-9 case. Complete specifications are included in SSPI bulletin C410-01.

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Diode Series

A series of sub-miniature silicon circuit diodes guaranteeing a controlled forward specification of 0.7 to 0.74 volts at 10 milliamperes has been announced by Silicon Transistor Corp. This high conductance controlled forward series, known as types STC 101 through 108, is ideal for application requiring ultimate reliability, as well as predictable forward characteristics as in transistor biasing, modulator and clamp circuits.

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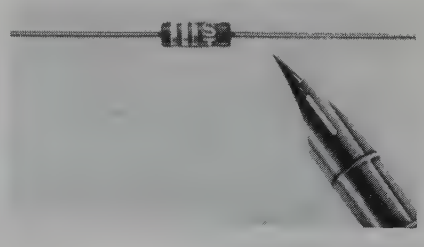

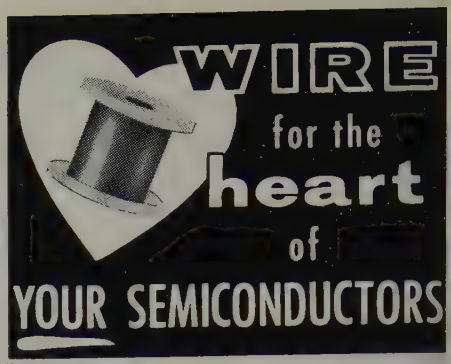

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Controlled Rectifier Series

A complete line of diffused silicon P-N-P-N controlled rectifiers was announced by Texas Instruments Incorporated. The P-N-P-N rectifier is a new four-layer semiconductor device which is expected to be used widely in regulated power supplies, reversing drives, light dimming devices, surge voltage suppression, latching relays and many other new applications. TI Type-130 series feature 50 to 400 volts in both PIV and breakover voltage with an average rectified forward current of 3 amps at 50°C, 1 amp at 125°C.

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Radiators & Manifolds

Relco Products Radiators for power transistors and rectifiers have radiating surfaces of 35 to 65 square inches, hard anodized insulating finish. For both convection and forced air cooling. Lightweight compact aluminum construction. Four types for greatest design flexibility. No insulating washer required for most applications. Black protective finish gives maximum thermal radiation. Integral extended surfaces for lowest thermal resistance. Universal design fits most power transistors. Manifolds have modular design for greatest flexibility, black anodized protective finish, compact aluminum construction.

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Silicon Diodes

Designed to meet military specifications, Type Numbers RD1356-1359 from Rheem Semiconductor Corp., have unusually high back resistance, up to 50,000 megohms at 25°C. Forward conductance is 100ma at +1 volt. Breakdown voltages range up to 200 volts. These units are available now in the standard subminiature glass package.

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Metal Oxides

Monsanto Chemical Company's Research & Engineering Division has announced that it now is making available to industry samples and technical data on a series of micro-fine metal oxides which the company has trademarked Micria. Numerous other micro-fine oxides of various metals in both spheroidal and laminar forms also have been produced at the division's research facilities. The extremely small particle size ranges and chemical properties of the oxides qualify them for use in many fields.

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Transistor Test Set

Transistor quality and performance may be quickly determined, through direct readout on a meter of three fundamental characteristics, with a new portable transistor test set developed by Metronix, Inc. Presented directly by the Model 545-B test set are the hybrid parameter Beta (h_{21}, h_{fe}), the input impedance (h_{11}, h_{ie}), and the collector cut-off current (I_{eo}). Measurement of these factors permits a rapid evaluation of whether a germanium or silicon transistor meets its stated specifications.

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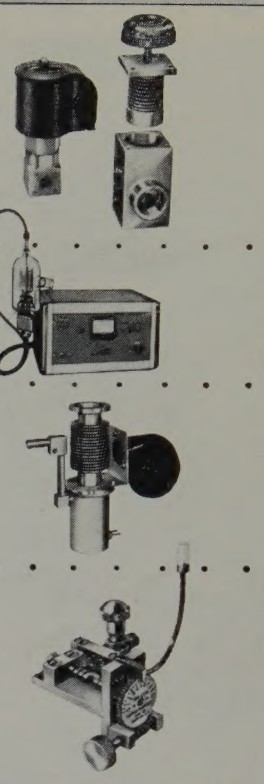
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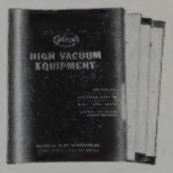
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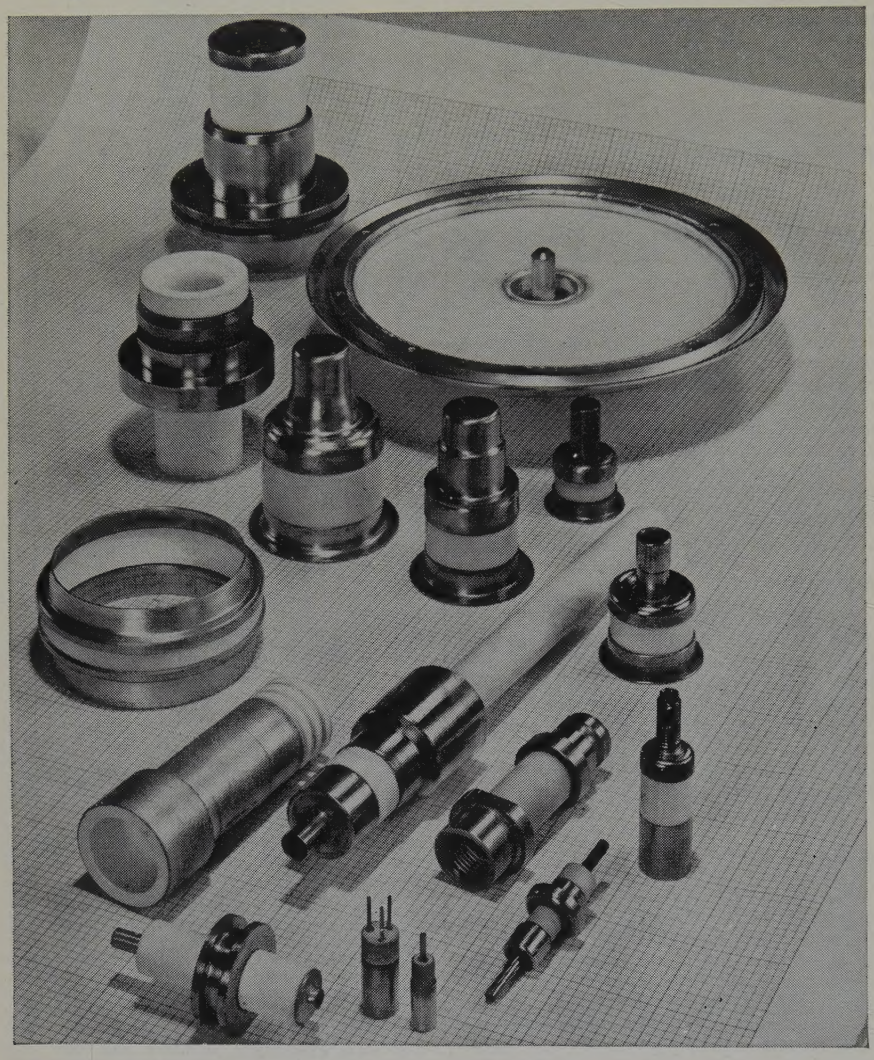

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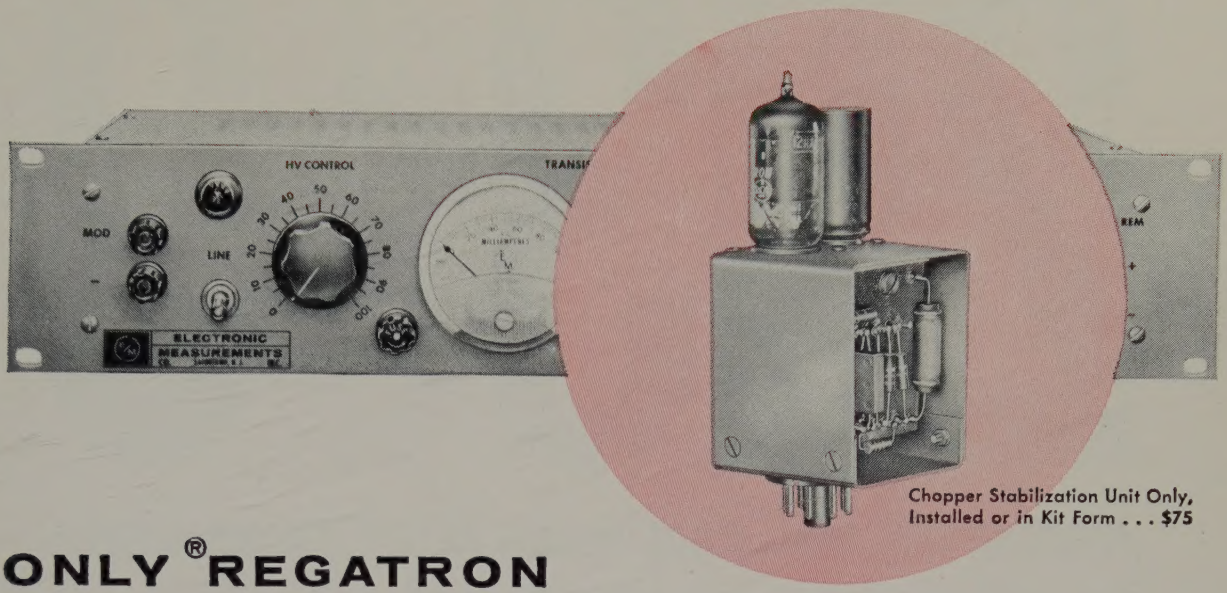

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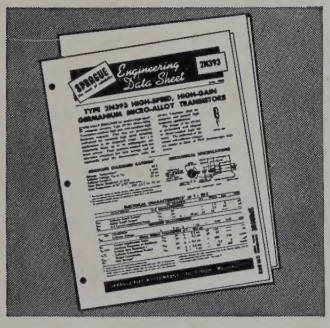

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Write for complete engineering data sheets to Sprague Electric Company, 467 Marshall Street, North Adams, Massachusetts.

ACTUAL SIZE

2N393

	Min.	Typ.
h_{FE}	20	95
f_{max}	40	60

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